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NATURE

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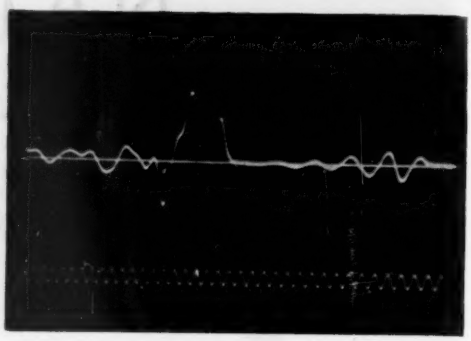

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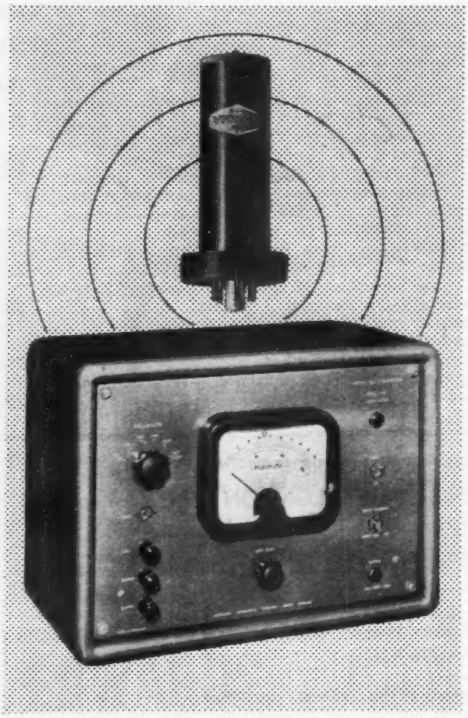

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UNIVERSITIES IN SOUTH AFRICA

AT the seventh congress of the Universities of the Commonwealth in July 1953, Prof. W. H. Hutt, of Cape Town, expressed the opinion that the subject of government and the universities was the most important problem of the modern world which confronts the universities. Much evidence could be found in the past three years to justify that statement; but scarcely anywhere has its nature been more clearly displayed than in South Africa. The device by which these relations have hitherto been so harmonious and fruitful in Great Britain does not depend entirely on the device itself: the University Grants Committee functions smoothly because there is clear understanding on both sides. On the Government side, the autonomy of the universities is respected because the nature and function of a university and the way in which it works are clearly understood. On the side of the universities, there has been a continuous attempt to adapt its service to the changing needs of the community, without surrendering that integrity and independence which a university must have if it is to fulfil its highest function and render the community the finest service in its power.

It is the absence of such understanding on the part of the South African Government that has led to the introduction in the South African Parliament of a Bill providing for *apartheid* in South African universities. This Bill is opposed by the so-called 'open' universities of Cape Town and the Witwatersrand, and although it must be recognized that, from the Nationalist point of view, this is a constructive Bill, honestly intended to further the cause of non-European education, the Opposition United Party took the unusual step of opposing its first reading. The Bill does not propose to curtail the avenues to learning which now exist until others are open; but, nevertheless, apart from the weighty practical objections to the Bill, Mr. J. H. Viljoen's attempt for the Government to dismiss protests and other opinions as frivolous shows how little the Union Government understands the character and function of a university.

The University of Cape Town and the University of the Witwatersrand are known as the 'open universities' because they admit non-white students as well as white students and aim, in all academic matters, at treating coloured students on a footing of equality with white students, and without segregation. They have for some years been under pressure to adopt a policy of *apartheid*, and the Bill which received its first reading on March 11 is the outcome of the failure of the Union Government to secure the voluntary co-operation of the two universities. The Bill was in fact withdrawn on a technical point, but is in substance being re-introduced.

The Union Government is seeking power to impose upon the universities a uniformity of practice, in accordance with its theory of *apartheid*. It proposes to establish a number of new university institutions for non-whites, some for Africans only and another—or others—for the Asian and coloured groups, and its intended legislation is to provide "that as separate universities for the various non-European races become available, the white universities will be prohibited from admitting non-Europeans". When this prohibition takes full effect, every university and university college in South Africa will be a segregated institution, closed to races other than the one prescribed for it by the Government, and each of the institutions for Africans appears to be intended for students from a particular group.

This action has been opposed by the councils, senates, staffs, students and graduates of both open universities in substantially similar terms. On December 12, 1956, the Council of the University of Cape Town, and on December 14 that of the University of the Witwatersrand, affirmed their opposition in principle to academic segregation on racial grounds, and asserted their conviction that the policy of academic non-segregation accords with the highest university ideals and has contributed to inter-racial understanding and harmony in South Africa. They have expressed the desire that their Universities be permitted to carry on their functions under the same conditions as hitherto, and that nothing be done to change or impede the Universities' policy of academic non-segregation. The University of Cape Town also affirmed its belief that separate academic facilities for Europeans and non-Europeans could not be equal to those provided in an open university. On December 18, when these resolutions were made public, it was announced that the Councils of the two Universities had agreed to organize jointly a conference, consisting mainly of senior members of their academic staffs, to prepare and publish a reasoned statement on the subject of the open universities in South Africa.

This statement, which has now appeared*, sets forth in firm but dignified argument the case for the open universities and the grounds on which they oppose the intended legislation. It is strongest in its defence of the principle of academic freedom, arguing lucidly and conclusively that the legislative enforcement of academic segregation on racial grounds is an unwarranted interference with university autonomy and academic freedom. Much of this argument has already been discussed in *Nature*, for example, in considering the world-wide significance of academic freedom (**173**, 555; 1954) and in discussing Dr. T. B. Davie's Hoernlé Memorial Lecture on "Education and Race Relations in South Africa" (**176**, 613; 1955); but it appears, unhappily, that the Union Government is unlikely to attach much weight to the arguments of principle or to trouble to justify its proposed action clearly and irrefutably.

* The Open Universities in South Africa. Pp. viii+47. (Published on behalf of the Conference of Representatives of the University of Cape Town and the University of the Witwatersrand, Johannesburg, held in Cape Town on 9, 10, and 11 January, 1957.) (Johannesburg: Witwatersrand University Press, 1957.)

While the practical objections are advanced somewhat less cogently, they are sufficient to dispose of the Minister's belief that he can give the non-Europeans something as good as they will lose when the restrictions on entry to the open universities come to mean total exclusion. The University of Cape Town, in its resolution of December 12, challenged the contention that separate academic facilities for Europeans and non-Europeans could be equal to those provided in an open university. The contention is plausible, and the Holloway Commission conceded that if the non-white students excluded from the open universities were to have substantially equal opportunities by the provision of proper facilities for them at other universities, there need be no clashing with the fundamental concept of academic freedom. Nevertheless, even the Holloway Commission found that such a policy was financially impracticable, and was forced to admit that in practice such facilities would mean a material retrogression in the university training of non-Europeans.

The Holloway Commission did not report clearly on costs, and the report of the interdepartmental committee, consisting entirely of officials, which the Government afterwards appointed, has never been published. The Holloway Commission, however, did put the capital cost of absorbing the non-white students now at the open universities into either the University of Natal or Fort Hare at £1,000 per student; but since the Union Government contemplates not an institution for a thousand students but several institutions each initially for a smaller number, it is probable that the cost per student would be three or four times that figure, if the material facilities are to be substantially equal to those at the open universities. The running costs accordingly are also likely to be several times greater than the average grant of £120 which the Government at present provides for each student at the open universities, and nearer the annual expenditure of £345 per student at the small University College of Fort Hare.

Whether the Union Government can afford, and will in practice appropriate, the capital expenditure of several millions and the considerably greater running costs to provide equal facilities for non-Europeans in this way is, of course, South Africa's affair; and it may well be that for tactical reasons the open universities do not in this statement stress the waste of resources involved by the Government's proposals. What they do emphasize with justice is the practical impossibility, even at such a price, of providing those conditions, not to be assessed in physical or monetary terms, without which no real equality or even comparison is possible. The calibre of the staff, even its recruitment, the extra-curricular activities and exchange of ideas outside formal lectures and laboratory classes, present far more difficult problems in the segregated universities if there is to be for the student—or the staff—substantially the same freedom to seek the truth, to communicate and receive knowledge and ideas as marks the open university. It has already been realized in the United States that inequality is inherent in segregated education, and the whole approach of the Union Government to the open universities in this matter engenders the profoundest scepticism that in the result any segregated university which it might establish would be allowed the freedom of utterance and investigation which is the glory of the true university and the condition of its existence.

The open universities advance other weighty practical arguments against the Union Government's proposals. Rejecting the view that the open universities constitute a danger to the existence of white South Africa, they contend that, on the contrary, unless Western civilization is communicated comprehensively to at least the *élite* of the non-white population, the very existence of the white man in South Africa will be in jeopardy. The open university is effectively fulfilling this task of communicating Western knowledge and values by that personal contact of the non-white with the actual daily practice of Western ways of thinking and living which is required and which is possible only in such a university.

No less important and practical is the argument, derived from experience, that a society, however successful it may have been in the past, will not long survive if it cannot cope with the tasks of a new era. For this reason, every civilized society tends to develop institutions which will enable it to acquire, digest and advance knowledge relevant to the tasks which are expected to confront it in the future. Of these institutions, the university is the most important, but it cannot fulfil such functions unless its members are left free to pursue new knowledge. The small minority who in any society are engaged in advancing, testing and disseminating knowledge must be free to organize their work in the way that seems to them to be the most conducive to efficiency and success; to impose on them subservience to some particular dogma, whether that of *apartheid* or any other, in place of the pursuit of truth and the advancement of knowledge is to frustrate their efforts.

The very severity with which the Union Government seeks to repress discussion of these issues and refuses either to recognize that there are two sides to the argument or to present cogent reasons for its proposed action supports what is said in this statement as to the danger of the Government's policy undermining the very fabric of South African society. Not only will the universities be unable to exercise effectively their most important function of throwing up new ideas and new knowledge and putting it to the test; they will also equally be unable to play their full part in the conflict of ideas and in fostering among their students the understanding, tolerance, sympathy and capacity for seeing the other man's point of view which are so essential to the development of an educated, humane and civilized perspective on race relations without which no multi-racial society can survive. The chapter in the statement published by the open universities in which this argument is developed is one of the ablest in the book; it brings out both the intensely practical implications of the

preservation of academic freedom and autonomy, and the way in which the open universities are also members of an international community of universities, sharing common ideals and traditions by virtue of which any particular university may on occasion find itself in conflict with sectional interests or with a narrow interpretation of national loyalties and interests.

Here indeed is shown how impossible it is to separate principle and practice: the open universities of South Africa, no more than any other university anywhere in the world, cannot permit interference without betraying their ideals and traditions. It is part of their duty to society to represent and maintain the ideals and principles which unite the community of universities and which indeed find expression in their name. To force a university to abandon its ideals and principles is not only to affront its dignity and restrict its legitimate activities: it is also to prevent its rendering its true service to society, and even in the long run to destroy its soul.

The open universities will thus have the universal support of the international community of universities in the stand they have taken against a measure which they believe will prevent them fulfilling their true function and rendering their most effective service to the community in which they are placed. The Union Government may be unmoved by the plain fact that, neither in the open universities nor elsewhere in the university world, are its proposed restrictions regarded as supported by the over-riding reasons which the Holloway Commission stipulated as required to justify any limitation of a university's autonomy. It may even be unmoved by the dignified warning from the open universities that racial harmony is a matter of slow evolution, and that while legislation cannot create racial harmony it can destroy the conditions under which it can grow. If, however, the Union Government is indifferent to the world-wide support which universities everywhere give the open universities in their stand for the four pillars of university freedom—the rights to decide for themselves what may be taught, how it may be taught, who may teach, and who may study—it condemns itself as attempting to lead South Africa into barbarism and the destruction of the fabric of its civilization. It is not simply requiring the open universities to reject the ideals and wisdom garnered in eight centuries of expression; it is forcing on South African society the closed mind, and excluding that open forum in which existing institutions and beliefs are tested, criticized and re-assessed, approved or disapproved in the light of the evidence available. That is the basis of adjustment and modification in a dynamic society. What is at stake in this proposal to force *apartheid* on the open universities of South Africa is not the future of the universities alone but that of South Africa itself; it may indeed decide whether disaster and bloodshed rather than co-operation and peace are to mark the future relations of black and white throughout that great continent.

QUANTUM THEORY OF FIELDS

Quantum Field Theory

By Prof. H. Umezawa. (Series in Physics.) Pp. xv+364. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1956.) 35 guilders; 70*s*.

THE quantum theory of fields is concerned with the most basic problems of modern physics; it is also no doubt the most complicated branch of quantum theory as regards the mathematical formalism. The student of theoretical physics is therefore liable to regard it as the crowning glory of theoretical research, and will consider the initiation into its secrets as his obvious ultimate ambition, from which he should be diverted only by lack of ability or of opportunity.

On closer acquaintance he will find it, at the present time, a much less rewarding field than he expected. The reason is that, in its application to electromagnetic interactions, the essentials of field theory are required only for determining very small corrections to a more simple-minded approach, the smallness of the corrections being related to the small value, 1/137, of the fine-structure constant. The great successes of the post-war years in refining theory and experiment have shown that such corrections can be calculated, and agree with observation, to an almost incredible degree of accuracy. Further progress here is limited by the sheer computational difficulties of carrying the theory to yet higher orders, and the difficulties in getting more accurate experimental data. It is doubtful whether this process of successive approximations is an approach to a rigorous solution of the equations of the present theory, and whether, in fact, such a solution exists. Any limit to the accuracy obtainable by the present methods is likely to lie far beyond the limits of practical computation or experimentation. (It is not impossible, however, that we are nearer to discrepancies, and thus to new clues, than the internal nature of the formalism compels us to assume.)

Whereas in this field the weakness of the interactions makes further investigations largely academic, the study of mesons and their interactions is held up by the opposite difficulty. The interactions are here so strong that none of the known mathematical methods can yield reliable answers, and the doubts about the consistency of the equations we are using become of real practical significance.

One cannot foresee when the next major step will be taken, or what its nature will be, but it is certain that many of the concepts of current field theory will play a part in it, and for this reason it is still important for new generations of research workers to acquaint themselves with the present theory, however academic it might appear for the moment. In an exposition of the subject the emphasis is bound to depend on the author's view of the ultimate importance, in a future theory, of the various present-day tools.

Prof. H. Umezawa's book is an interesting contribution to the literature of the subject. One of its unusual features is the stress on the most general wave equations (including those for spin greater than 1) and on very general action principles. While there is as yet no strong reason to assume the existence of particles of high spin, it is interesting to know about possible generalizations. For this reason the quan-

tization of fields is introduced only on p. 136, and the interaction between fields on p. 179. Thus the details of the formalism of renormalized field theory are condensed into a fairly small space.

The mathematical derivations are usually elegant and often original, as one would expect of an author who is thoroughly at home in the subject and who has made many original contributions to it. But the presentation is not easy to follow; the reasons for choosing an expression, and its meaning, are often explained only very briefly. The book is therefore scarcely suitable for a beginner, but for a reader with some knowledge of the subject it provides many interesting new angles.

The historical introduction is a brief but useful survey; it is interesting also because it refers to some work of the Japanese group which is not adequately known in the West.

The English text was written during the author's stay in Manchester. A preface by Prof. Rosenfeld describes graphically the efforts to overcome the language difficulty with the enthusiastic help of the rest of the department. Unfortunately, many errors and roughnesses remain. While most are harmless, some make it quite difficult to follow the author's meaning. It seems a pity the book had to be published in Holland, not only because many English readers will be discouraged by the price, but also because some of the more obvious errors might have been caught by the printer's reader. Aside from the language question, the standard of typography is a little disappointing for a book of this price.

R. E. Peierls

RADIOACTIVITY AND NUCLEAR PHYSICS

Phénomènes radioactifs et introduction à la Physique nucléaire

Par Prof. Georges Gueben. 2e Édition. Pp. 312. (Liège: Éditions Desoer; Paris: Dunod, 1956.) n.p.

THIS introductory book, based originally on two lecture courses at the University of Liège, is intended, the author states, to present the minimum of knowledge necessary for embarking on specialized books and reviews. The present edition, following the conference in 1955 held at Geneva, has been revised to include some recent advances in the subjects.

The general properties of radioactive substances and their radiations are set out through accounts of the classical experiments which established them. Through this approach, the author succeeds in recapturing some of the spirit of discovery which attended these experiments. A special study of the natural radioelements, introduced in small type as unessential to the main text, is full of interesting information not generally found in a book of this type.

The concept of the nuclear atom is developed through Rutherford's theory of scattering for alpha particles and supported by arguments based on radioactivity. A chapter on nuclear collisions is followed by an account of Gamow's theory of nuclear fields, and this prepares the reader for a discussion of artificial disintegration of the nucleus and its results, which are fairly thoroughly treated in two separated chapters.

Types of particle accelerators are briefly described, and an account of nuclear fission is followed by a chapter on chain reactions and the basic principles of nuclear reactors. A treatment of transuranic elements follows in which some unfamiliar names for elements 99 and 100 will be noticed.

Some applications of radioactivity are next described, though these make rather an inadequate, and in places (for example, the section on thickness gauges) even misleading, illustration of the established and potential techniques. Considering the wealth and diversity of examples described at the 1955 Geneva Conference, to which the author refers in his preface, this part of the book is disappointing.

Rather more satisfying is the account of the significance of radioactivity in geological studies, including methods of geological age determination. Cosmic rays also are treated more thoroughly and on the basis of experimental evidence.

The book concludes with three chapters on nuclear properties and structure, in which such properties as binding energy and its consequences are carefully discussed. There is an additional chapter in small type on radiation measuring techniques.

To attempt to condense even the fundamentals of such a wide subject into a single volume is a formidable task and, as the author admits, there are some omissions which the interested reader is obliged to make up by supplementary reading. Some more adequate references to published papers and specialized books would have helped greatly towards this end. Much could have been gained also by making the figures more self-explanatory: few have adequate captions and some are not even referred to in the text.

The overall coverage of subjects, however, is remarkable: few important topics escape mention. The dismissal of bremsstrahlung in three and a half lines, as compared with nearly a page accorded to neutrinos, illustrates the concern of the book with academic fundamentals rather than practical applications. It is a pity that the experimental detection of the neutrino could not have been included in the new edition.

Practical experimental techniques are rather sketchy, though this shortcoming is partly redeemed by an additional chapter on counting techniques. Autoradiography is inadequately described, for example, and its potentialities for research are largely missed.

The book is valuable, however, as a logical cohesive outline of the fundamentals of radioactivity and nuclear physics, well within the comprehension of the undergraduate. The general reader should find it informative and to the more serious student it will serve as an introduction to the more detailed study of these subjects.

J. L. Putman

POLLINATION OF FLOWERS BY INSECTS

Einführung in die Blütenökologie

Von Dr. Hans Kugler. Pp. 278. (Stuttgart: Gustav Fischer Verlag, 1955.) 28 D.M.

THE interest in the complicated interrelations between flowers and the animals—mostly insects—which pollinate them is perennial. The present book brings our knowledge of the subject up to date at a relatively elementary level. It is primarily written from a German point of view and nine-tenths of the four hundred and seventy-one references are to the

German literature. Even such a large work as "Experimental Pollination" by Clements and Long is not mentioned; the German references, however, seem to be sufficiently full. The most useful feature of the book is the general review of the problem; of types of flower and of types of pollination, including pollination by wind, water, bats, birds and insects.

As insects are of special importance, they are considered in much more detail and the colour, structure and scents of flowers are considered in relation to what is known of the physiology and behaviour of the insects. The author is probably primarily a botanist and the statements about insects and the illustrations of their structure are much less authoritative. Thus, *Panorpa* is called a Neuropteran and *Forficula* an Orthopteran. About one-third of the book is taken up by a systematic consideration of flowers classified according to their pollination mechanisms. The numerous illustrations of flowers are clear and informative, but those of insects, apart from some excellent photographs, are often much too diagrammatic. In spite of the author's insistence on ecology in the title, this aspect of the problem is really scarcely touched on.

There is still little information as to the significance of different types of insects in pollinating flowers of different kinds and we know still less of the influence of different habitats on these relations. While the present volume forms a useful introduction, there is still need for another book with a more ecological approach.

O. W. RICHARDS

SYSTEMATIC AND FAUNISTIC ZOOLOGY OF SOUTH AMERICA

Beiträge zur Neotropischen Fauna

Herausgegeben von Prof. Dr. Erich Titschack und Dr. Hans Wilhelm Koepcke. Band 1, Heft 1. Pp. 68. (Jena: Veb Gustav Fischer Verlag, 1956.) 10 D.M.

IN 1936 an expedition was sent from Hamburg to southern Peru, but for obvious reasons it was not possible to publish the results, to the systematic parts of which a considerable number of experts contributed, until comparatively recently. They were produced under the editorship of Prof. Erich Titschak, of Hamburg-Altona. Now he, together with Dr. Hans Wilhelm Koepcke, of Lima, appears as editor of a new periodical, *Beiträge zur Neotropischen Fauna*, which, like the volumes just mentioned, is published by Gustav Fischer, of Jena. It is to be devoted mainly to systematic and faunistic zoology and other studies subserving these ends. The main languages are German, Spanish and Portuguese, but contributions in languages other than German must be furnished with a résumé in that language.

In the introduction, in giving some explanation for the addition of a new journal to the many now appearing, it is pointed out that South America, the Neotropical region of zoogeography, is a clearly defined region geographically and a very rich and characteristic one zoologically. In spite of the work that has been done, many groups of animals have scarcely been touched, if at all, and most of the remainder far from satisfactorily dealt with. Further, it is emphasized that the relevant information is widely scattered in many publications. Of course, it will not stop the appearance of papers in the publications of museums and institutes and in the reports of expeditions, and authors will still continue to contribute specialist studies to the periodicals catering for their own particular field. It is hoped that the new journal will lessen this difficulty to some extent by making provision for descriptions of new species, monographic treatment of small or large units and revisions of groups furnished with identification keys for South American animals.

The inaugural part of 68 pages contains papers on Peruvian fishes, Brazilian ostracods and new polychætes from Brazil and El Salvador. It is well illustrated and produced in the excellent style one associates with the house of Fischer. The parts will appear from time to time and at first will not exceed ten sheets in a year. The only indication of price is a small slip stuck on to the first page saying that its price is D.M. 10, but a more important omission for a work dealing with systematics is the absence of a publication date more precise than just 1956.

C. H. O'DONOGHUE

TARSKI'S PAPERS

Logic, Semantics, Metamathematics

Papers from 1923 to 1938. By Alfred Tarski. (Translated by J. H. Woodger.) Pp. xiv+471. (Oxford: Clarendon Press; London: Oxford University Press, 1956.) 60*s*. net.

THIS book contains the translation into English of seventeen of Tarski's major writings on logic, semantics and metamathematics which were published before the Second World War. With two exceptions (Papers 2 and 11) it does not contain his papers on foundations of special mathematical disciplines or any of his papers of a pronouncedly mathematical character. Their arrangement corresponds to the chronological order in which they first appeared in print.

The articles have been provided by the author with cross-references to other articles in the volume and with notes referring to later developments. Some new remarks have also been added. In two of the articles (2 and 6) Tarski has inserted several passages to amplify and clarify their contents.

The original idea was that Tarski should see the translation before it got into print, but considerations of time and space and the death of Kalicki, who was assisting Tarski, made it impracticable to do this with the whole of the manuscript, so Tarski saw only galley proofs of some of the translation, in which, obviously, extensive changes were impossible.

Prof. J. H. Woodger is to be congratulated upon completing the arduous task of translation and presenting in a handy form papers many of which originally appeared in journals difficult to obtain. The translation is accurate and readable, so that one almost gets the impression that the papers were originally written in English. The volume forms a very valuable addition to the library of a specialist in mathematical logic.

The titles of the seventeen papers are: (1) On the primitive term of logistic (Tarski's doctoral dissertation, 1923); (2) Foundations of the geometry of solids (1927); (3) On some fundamental concepts of metamathematics (1928); (4) Investigations into the sentential calculus (with Łukasiewicz, 1930); (5) Fundamental concepts of the methodology of the deductive sciences (1930); (6) On definable sets of

real numbers (1931); (7) Logical operations and projective sets (with Kuratowski, 1931); (8) The concept of truth in formalized languages (1931, in Polish; the translation is from the German translation of 1936. This article occupies about one-third of the book); (9) Some observations on the concepts of ω-consistency and ω-completeness (1933); (10) Some methodological investigations on the definability of concepts (1934); (11) On the foundations of Boolean algebra (1935); (12) Foundations of the calculus of systems (two papers, 1935, 1936); (13) On the limitations of the means of expression of deductive systems (with Lindenbaum, 1935); (14) On the extensions of incomplete systems of the sentential calculus (1935); (15) The establishment of scientific semantics (1936); (16) On the concept of logical consequence (1936); and (17) Sentential calculus and topology (1937).

From this it is seen that the selection is well chosen and all the important papers are present. It was wise not to publish the original on one page and the translation on the opposite page, for this would have doubled the price of the book. But it would have been helpful if the page numbers of the German version of 1936 had been indicated in the long, and much referred to, article 8.

Mathematical logicians are greatly indebted to Prof. J. M. Woodger for making these important papers easily readable and available.

S. W. P. Steen

PRODUCTIVITY CHANGES AND REWARD

Dynamic Factors in Industrial Productivity

By Seymour Melman. Pp. xiii+238. (Oxford: Basil Blackwell, 1956.) 22*s*. 6*d*. net.

Measurement of Responsibility

A Study of Work, Payment, and Individual Capacity. By Dr. Elliott Jaques. Pp. xiii+143. (London: Tavistock Publications, Ltd., 1956.) 15*s*. net.

BOTH these books are concerned with the problems of administrative overheads. Mr. Melman has undertaken a survey of all the effects of rising labour cost on the methods used in production in Britain and the United States. Dr. Jaques approaches the problem from that of an individual organization and attempts to devise a method for assessing the just reward for varying levels of responsibility. Both authors appreciate that unless there is a degree of contentment among the workers in any organization, productivity will suffer.

Mr. Melman's wide review sets out not only the results of his inquiry but also the methods used in his investigation. The book is therefore of considerable interest to research workers in his field, and the general conclusions have immediate bearing on the practices of industrial management in Britain. The problem posed by Mr. Melman is that of discovering "what factors underly the increased mechanization of industrial production methods in England after World War II". He believes that the primary determinant was changes in the relative cost of man- and machine-hours.

The first part of Mr. Melman's book sets out the method he used in collecting his data and his conclusion that only the cost of alternative labour and machine hours changed substantially from 1938 to 1950. He sees definite paths of decision making, through which the change of costs was linked with production mechanization. This observation led Mr. Melman to turn to an investigation of the significance of the growth of administrative overheads in manufacturing firms in relation to productivity changes. An interesting conclusion in this section of the book is that he found no evidence to suggest that any concerted policy-making, related to productivity, was undertaken by individual or group managements with respect to the growth of the administrative staff. Administrative overheads were found to vary with the addition or subtraction of administrative functions and did not move in proportion to increases of productivity.

In the third section of his book Mr. Melman compares alternative labour and machine costs in the United States and Britain. He shows that in the United States the rise in the ratio of administrative costs to productive labour cost has been exceeded by the rise in productivity. In Britain the degree of growth of administrative overheads has exceeded that of industrial worker productivity.

The final section of the book is a balanced review of the findings and suggests the implications behind them. Mr. Melman concludes that there is no unilateral line of action that any one interested group in the economy may take to raise productivity. Productivity changes are a joint product of employer/employee participation.

Dr. Jaques takes one of the factors indicated in Mr. Melman's book and considers this in considerable detail. It is abundantly clear to everyone associated with industry that the recurring difficulties in settling wage disputes have an adverse effect on productivity. Techniques such as 'job evaluation' are an advance on straight bargaining in wage discussions, but difficulties arise in attempting to assess responsibility. The findings of Dr. Jaques's research will be of considerable interest to all workers in the field of wage negotiations. He concludes that individuals estimate their weight of responsibility by the amount of discretion they are required to exercise in doing their work. Dr. Jaques believes that the amount of responsibility can be measured by the span of time during which an individual exercises discretion on his own account. He has observed that individuals with the same span tend to expect comparable financial rewards.

The book is interestingly and stylishly presented so that it should appeal to a wide public interested in the problems of administration. Part 1 poses the problem. Part 2 details the experiment he carried out in collaboration with the Glacier Metal Company. Part 3 deals with theoretical considerations. Dr. Jaques realizes that increased mechanization may lead to a de-skilling of work. This trend is clearly shown in Mr. Melman's analysis. Unless this effect is recognized and steps taken to deal with it, stress and tension gradually increase and an attempt is made to freeze the situation in order to prevent further reduction. Dr. Jaques indicates useful lines of action to prevent this situation arising.

Both authors, although looking at the problem from widely different points of view, conclude that each organization and indeed each nation must build its business on a pattern that satisfies the needs of the people involved in the undertaking. Unless employer and worker are in a satisfactory relationship to each other the efficiency of the organization will be reduced.

Leon Fontaine

The Pocket Guide to Wild Flowers

By David McClintock and R. S. R. Fitter, assisted by Francis Rose. Pp. xii+340+112 plates. (London: William Collins, Sons and Co., Ltd., 1956.) 25*s*. net.

THERE seems to be no limit to the spate of popular books on the English flora and it is with a feeling of irritation that one picks up the latest of them, a book "designed to enable *anyone* without botanical knowledge, to identify . . ." A perusal of the book turns the pessimist into an enthusiast because this is not just another book on wild flowers. It is something that makes a very serious attempt to justify the publisher's note on the jacket and the authors may be said to have succeeded admirably.

This then is a book which can be recommended to anyone who takes an interest in the countryside, for the very numerous keys and hints, couched in simple language, *will* enable anyone to run down their plant with comparative ease. The book is richly illustrated with plates in colour and with numerous line drawings. It has an index to popular names and one to the Latin names. It is altogether an excellent work which the reviewer wishes had been available when he was a boy. N. L. BOR

An Introduction to the Botany of Tropical Crops

By Leslie S. Cobley. Pp. xv+357+82 plates. (London: Longmans, Green and Co., Ltd., 1956.) 37*s*. 6*d*. net.

IN this useful book the author has given an account of the botany of the main and subsidiary tropical crops, illustrated by many good photographs and diagrammatic line drawings. The extensive and varied subject-matter, in twelve chapters, includes the cereal crops, sugar cane, fibres, oil seeds, leguminous crops, starch storage crops, spices, beverages, drug plants, cultivated fruits, vegetable crops, rubber and essential oil crops, together with selected bibliographies and an index of botanical names. In all, more than one hundred and fifty different useful species are described. The scope of the treatment may be indicated by noting that, among the essential oil crops, fourteen different sources are described; rubber is described from eight sources; fibres from twelve sources; and so on. This book is a commendable undertaking, and the author may be congratulated on having provided a wide circle of readers with a concise, interesting and readable introduction to the botany of tropical crops. C. W. WARDLAW

Integral Functions

By Dr. M. L. Cartwright. (Cambridge Tracts in Mathematics and Mathematical Physics, No. 44.) Pp. viii+135. (Cambridge: At the University Press, 1956.) 18*s*. net.

THE theory of functions which are of finite order in an angle, to which Dr. Cartwright has herself made many contributions, is here collected into a single volume. The first chapters give the machinery required, such as various maximum modulus theorems and the powerful Nevanlinna formula. The third chapter is a detailed study of the Phragmén–Lindelöf theorems and of the Phragmén–Lindelöf function $h(\theta)$, which, roughly, compares $\log|f|$ with r^ρ, where ρ is the order of the function. Chapter 4 defines the Lindelöf proximate order, and thus leads up to the possibility of obtaining very general results, discussed in full detail in Chapters 5 and 6, on the relations between the growth of a function and the distribution of its zeros. Chapter 7 deals with the lines of Julia, connected with the concept of exceptional values which a function cannot take, while perhaps the most interesting part of the final chapter is that which relates the exceptional values to the singular points of the Borel transform of the function. Dr. Cartwright's exposition shows classical specialized analysis at its best. T. A. A. BROADBENT

Irrational Numbers

By Prof. Ivan Niven. (Carus Mathematical Monograph, No. 11.) Pp. xii+164. (Buffalo, N.Y.: Mathematical Association of America, 1956. Distributed by John Wiley and Sons, Inc., New York; and Chapman and Hall, Ltd., London.) 24*s*. net.

PROF. NIVEN'S book carries on the high traditions of the Carus Monographs by providing a concise and illuminating account of an important topic. His title is slightly misleading, for he is concerned not with the definition and construction of irrational numbers but with their main properties, particularly those connected with number theory and Diophantine approximation. Pre-requisite knowledge is elementary, except in the later chapters, where some acquaintance with algebraic numbers and with function theory is expected. Typical results proved are: if r is rational, $\cos r$ is irrational; almost all real numbers are normal to every base, a normal number being one in which all blocks of digits of the same length occur with equal frequency; the theorem of Lindemann, which includes the transcendence of e and π as special cases; the Gelfond–Schneider theorem (1934), that if a and b are algebraic numbers, where a is neither zero nor unity and b is irrational, then a^b is transcendental. Since almost all real numbers are transcendental, this goes some way to removing the paradox that most of us, if asked for an example of a transcendental number, would find it hard to go beyond e or π; perhaps the stimulus of Niven's book will encourage someone to settle the character of Euler's constant.

Atlas Coeli 1950.0

By Antonin Bečvář. Pp. 111+16. (Praha: Nakladatelství Československé Akademie Věd, 1956.) 60 Kcs.

THIS convenient and very useful series of star charts, constructed under the supervision of the Director of the Rocky Lake (Skelnate Pleso) Observatory, was originally published in Prague in 1948. A reprinted edition, from duplicate negatives, was published in 1949 by the Sky Publishing Company, Cambridge, Massachusetts. The most obvious change in this new Prague edition of 1956 is the use of colour to mark the galactic and globular clusters, the planetary and extragalactic nebulæ and the bright and dark galactic clouds. The usefulness of the Atlas has also been increased by indicating the positions of radio-stars listed by Ryle, Smith and Elsmore (*Mon. Not. Roy. Astro. Soc.*, **119**, 110; 1950) and B. Y. Mills (*Austral. J. Sci. Res.*, **5**, 266; 1952). The manner in which the brightness, duplicity and variability of the stars brighter than visual magnitude 7·75 is indicated is the same as that in the previous editions, but the new charts contain not only the Bayer letters but also the Flamsteed numbers of the stars in each constellation. The sixteen 16½ in. × 23 in. charts are bound in attractive, stiff covers and a plastic templet is supplied to facilitate accurate determination of the co-ordinates.

OBSERVATION OF DISLOCATIONS IN METALS BY MEANS OF MOIRÉ PATTERNS ON ELECTRON MICROGRAPHS

By D. W. PASHLEY, J. W. MENTER and G. A. BASSETT

Tube Investments Research Laboratories, Hinxton Hall, Cambridge

IN recent years, several workers[1–5] have observed fringes with spacings from 20 A. upwards in electron microscope images of overlapping crystals. It is now well established[5] that these fringes may be interpreted as a moiré pattern arising from the coincidence of the projected planes of atoms in the two overlapping lattices. In a recent paper, Uyeda and Hashimoto[6] show that the moiré patterns are modified by dislocations in either lattice, and that in favourable circumstances the dislocations are clearly recognizable in the moiré pattern.

We have recently carried out independent experiments in these Laboratories, in which dislocations in metals are revealed in moiré patterns. All previous work seems to have resulted from studies on fortuitously overlapping crystals, with small angular misorientations, so that the patterns have been seen comparatively rarely. Our technique allows deliberate overlapping in a predetermined relative orientation; pairs of crystals of similar structure, but different lattice parameters, are used and the two are prepared in exact parallel orientation. This allows a much greater control of the geometry of the formation of the patterns than is possible with the rotationally misoriented crystals, and eases the interpretation of effects due to dislocations.

The Optical Analogue

Uyeda and Hashimoto[6] have described an optical analogue which demonstrates the effect of dislocations on the moiré pattern, for the case of two rotationally misoriented crystals. We have shown, both by analysis and by means of an optical analogue, that edge dislocations are made directly visible in our system.

Figs. 1*a* and 1*b* show two line gratings, one of which contains an edge dislocation. If these two are superposed, with relative spacings such that five spacings of 1*a* match with about six spacings of 1*b*, then the moiré pattern is as shown in Fig. 1*c*. The extra line associated with the edge dislocation is clearly visible in this pattern; thus the moiré pattern is effectively a magnified image of the dislocated grating. However, the optical analogue can be used to show that the exact form of the 'strain field' of the dislocation in the moiré pattern depends upon the way in which the two lattices are superposed. In Fig. 1*c*, the extra line of Fig. 1*a* has been made coincident with a line of Fig. 1*b*; if this is not done, then the moiré pattern becomes somewhat distorted, although the extra line is still clearly visible.

Resolution

The great advantage of the system in the case of electron microscopy is that, although it has not yet been found possible to resolve directly the lattice of a metal (see, however, ref. 7), it is possible to resolve the lattice indirectly by means of the moiré pattern. The spacing of the moiré pattern is given by $\frac{d_1+d_2}{d_1-d_2}$, where d_1 and d_2 are the spacings of the two elementary gratings; thus by a suitable choice of d_1 and d_2, the moiré spacing can be made sufficiently large to allow the pattern to be resolved.

Preparation of Specimens

An extensive coherent single crystal (111) film of gold is prepared by an evaporation method which will be described in detail in a later publication. A second metal is then evaporated on to this as substrate, such that oriented growth occurs, to give a composite film of two metals each about 200 A. in thickness. When nickel, copper, cobalt, palladium

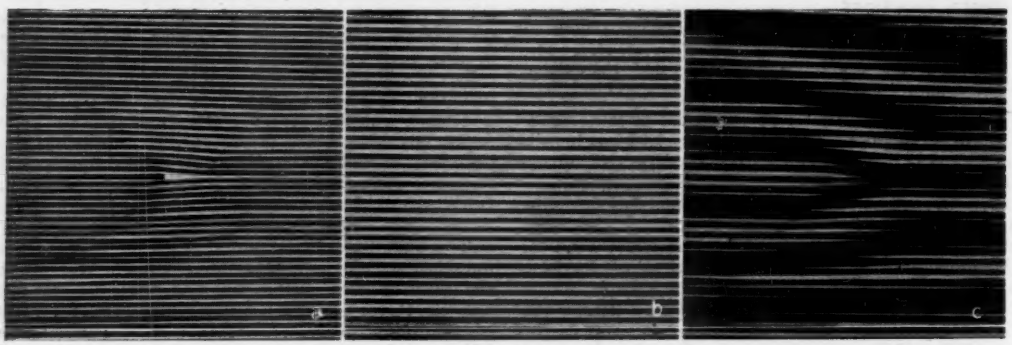

Fig. 1. Optical analogues demonstrating moiré effect with parallel gratings of different spacing. (*a*) Grating containing single edge dislocation. (*b*) Perfect grating. (*c*) Moiré pattern obtained by superimposing *a* upon *b*, showing appearance of edge dislocation in pattern

Table 1

Metal	Crystal spacings (A.)		Moiré spacings (A.) when combined with parallel gold	
	$(02\bar{2})$	$(42\bar{2})$	$(02\bar{2})$	$(42\bar{2})$
Nickel	1·24	0·719	9·2	5·3
Cobalt	1·26	0·725	9·8	5·7
Copper	1·28	0·737	11·3	6·5
Palladium	1·37	0·792	29	17
Platinum	1·38	0·798	35	20

and platinum deposits are used, parallel orientation occurs, so that the specimens have their $(02\bar{2})$ and $(42\bar{2})$ type planes perpendicular to the plane of the foil. It is these planes which are used as the elementary gratings in the formation of the moiré patterns. A list of the expected moiré spacings is given in Table 1.

Interpretation of Patterns

All the combinations listed in Table 1 give extremely good moiré patterns with remarkable consistency. Fig. 2 shows an example obtained from a gold–palladium specimen. In some regions more than one set of lines is apparent, giving the effect of a two-dimensional grating. This can be understood when the diffraction conditions in the specimen are considered. Dowell, Farrant and Rees[5] have shown the intimate relationship between the moiré pattern and double diffraction by the two overlapping crystals. The spacing of the moiré pattern corresponds with that expected from the 'Bragg angle' of the doubly diffracted beam. For the resolution of periodic structures in the electron microscope, it has been shown by Menter[7] that the Abbe criterion applies, that is, it is necessary that the undeviated beam and the first-order diffracted beam from the set of planes to be resolved shall pass through the objective aperture to the image. Similarly, the beams which are essential for the formation of the moiré pattern are the undeviated beam and that which has been diffracted by a given set of planes in each

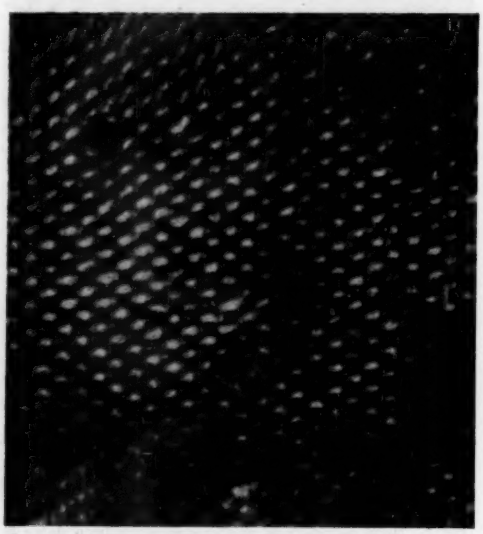

Fig. 2. Moiré pattern obtained by superposition of thin gold and palladium single crystal films in parallel orientation. Several different sets of lines are simultaneously resolved giving the effect of a two-dimensional grating. (× 850,000)

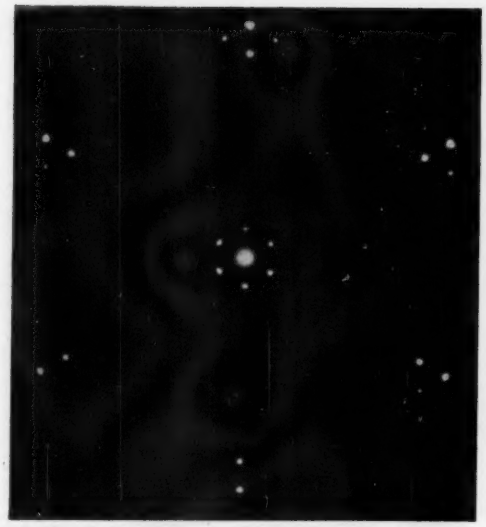

Fig. 3. Electron diffraction pattern from composite single crystal film of copper on gold showing double-diffraction effect. The group of spots close to the central spot are the essential image-forming beams for the moiré pattern

lattice, but in opposite senses; this doubly diffracted beam is almost coincident in direction with the incident beam. The double diffraction effect is illustrated in Fig. 3, which is a diffraction pattern from a copper–gold specimen. The variation of the pattern from one region of the specimen to another arises simply from slight buckling of the foil, leading to varying diffraction conditions from one place to another, so that different sets of planes are resolved in different regions.

The spacings in the moiré patterns are slightly higher than those given in Table 1. However, abnormal lattice spacings are often observed with thin films, and the moiré spacings are consistent with the spacings deduced from the diffraction patterns to within about 10 per cent. A more accurate calibration of the magnification of the electron microscope is required before this consistency can be tested to greater accuracy.

Observation of Dislocations

The moiré patterns contain many irregularities, some of which can be readily interpreted in terms of dislocations. In Fig. 4 several cases of edge dislocations are visible, the associated extra plane being imaged in the moiré pattern as in the optical analogue of Fig. 1*c*.

Although pure edge dislocations lie in [211] directions inclined at 70° to the foil surface, the extra plane of the dislocation is very clearly resolved. In the case of a face-centred cubic structure, an edge dislocation of unit strength has a Burgers vector of $[\frac{1}{2}\,\frac{1}{2}\,0]$, which has a magnitude of $a/\sqrt{2}$. Since the (220) planes have a spacing of $a/2\sqrt{2}$, there are two extra (220) planes associated with such a unit dislocation, as was first pointed out to us by Dr. P. B. Hirsch and Mr. M. J. Whelan. An example of this is shown in Fig. 5. It is readily shown that an edge dislocation with a Burgers vector which is not perpendicular to the set of planes being resolved will not necessarily give rise to two extra lines on the moiré

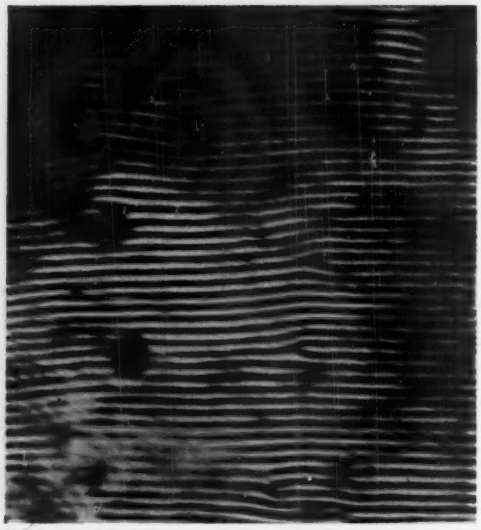

Fig. 4. Moiré pattern from different area of specimen shown in Fig. 2 with several examples of edge dislocations. (× 500,000)

pattern. Thus edge dislocations with a Burgers vector of $[0\ \frac{1}{2}\ \frac{1}{2}]$, $[0\ \frac{1}{2}\ \bar{\frac{1}{2}}]$, $[\frac{1}{2}\ 0\ \frac{1}{2}]$ or $[\frac{1}{2}\ 0\ \bar{\frac{1}{2}}]$ have just one extra (220) plane associated with them. Many dislocations of this type are visible on Fig. 4.

The general waviness of the moiré pattern is probably due to slight relative misorientations of the gold and palladium. It can be shown that if the crystals are misoriented by a small angle α about the normal to the foil, the moiré pattern will rotate about the same axis through an angle of $\frac{\alpha d_1}{d_1 - d_2}$, which is about 21α for the gold–palladium specimen. Thus the moiré pattern is very sensitive to lattice perfection and orientation.

Many other features on the moiré patterns are being studied and analysed. We have tentatively interpreted some effects as due to dislocation lines containing screw components.

Although the moiré patterns have been obtained with all of the combinations indicated in Table 1, the patterns from gold–palladium and gold–platinum are the most striking, because they have a large spacing. They are readily visible on the fluorescent screen of the electron microscope (a Siemens Elmiskop 1 in our case). This is important, since it means that movement of dislocations can cause visible changes in the moiré patterns, so that dislocation movement can be followed by the displacements which take place in the lattice planes. Such movement has already been observed on several specimens, as a result of the electron bombardment, and attempts are being made to record the movements. Observations of this type are essentially complementary to the study of dislocation movement by contrast changes due to lattice strain, already made by Hirsch, Horne and Whelan[8] in thin aluminium specimens.

Conclusions

The technique provides a new means of studying dislocations and their movement in metallic foils. To a large extent, the method overcomes the limitation imposed by the inability to resolve directly the lattice of a metal, although we are continuing to explore the possibility of achieving this, since this would allow the strain-field associated with a dislocation to be plotted in more detail.

Experiments are in hand to allow dislocation movements revealed via the moiré patterns to be studied during controlled plastic deformation and controlled annealing of specimens inside the electron microscope. We also intend to apply the moiré technique to the study of alloy formation, order–disorder phenomena, and the growth of oriented layers (particularly oxides on metals).

Finally, it is worth noting that the system of two parallel oriented metallic foils of different lattice spacings provides an excellent means of constructing a simple electron interferometer. Marton, Simpson and Suddeth[9] have used a system of three similar foils to obtain, by successive crystal diffraction, two beams which can be made to interfere. They obtain fringes of low intensity and contrast, and are limited to fringe spacings of about 1650 A. In the system used here, the moiré pattern is very bright, and the spacing of the fringes can be adjusted readily from about 5 A. upwards. The fringes can be considered to arise from the interference of one of the doubly diffracted beams of Fig. 3 with the undeviated beam. It is therefore possible to put a thin foil of any given material in the path of one of the beams, so as to cause a displacement of the corresponding set of fringes. This displacement can be used for the determination of the refractive index of the material in the electron beam, and provides a direct means of measuring the inner potential of crystals.

We thank Dr. T. P. Hughes and Dr. F. P. Bowden for their interest and encouragement in this work, and the Chairman of Tube Investments, Ltd., for permission to publish this paper. We are indebted

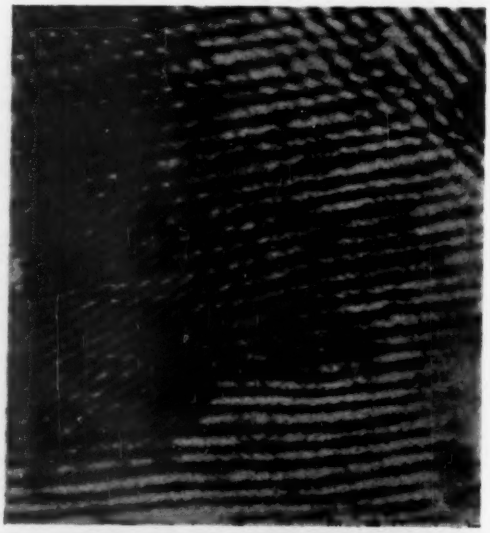

Fig. 5. Moiré pattern from another area of specimen shown in Fig. 2 with an example of an edge dislocation with its Burgers vector oriented perpendicular to set of planes giving rise to lines of moiré pattern. In this orientation two 'extra planes' appear in the pattern. (× 750,000)

to Dr. A. L. G. Rees, of the Division of Chemical Physics, Commonwealth Scientific and Industrial Research Organization, Melbourne, for sending us manuscripts of unpublished work.

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BIOLOGICAL EFFECTS OF RADIATION

AN open meeting was held on March 7 at the Institute of Biology under the title "Aspects of Radiotoxicity", with the aim of clarifying some of the problems arising from the increasing level of radiation. Dr. H. O. J. Collier, in the chair, set the evening's challenging tone to the scientist by opening the discussion with the quotation, "Man, proud man, drest in a little brief authority, . . . plays such fantastic tricks before high heaven, as make the angels weep". This challenge was taken up by Prof. J. Rotblat, who spoke on the physical aspects of radiation damage, and by Prof. L. Penrose, a member of the Medical Research Council Committee (1956) for the study of radiation hazards, who discussed biological damage, including the genetic effects.

Prof. Rotblat began by stressing the complexity of the problem. On the physical aspect alone, and confining the discussion to ionizing radiations, there is a multitude of particles to consider, from electrons to fission fragments, with widely differing energies, penetrating powers and types of secondary reactions produced. Compared, however, with the chemical, biochemical and biological processes contributing to radiation damage, the nature of which is still obscure, the physics of radiation damage is fairly well understood. The passage of radiations through matter gives rise to excitation and ionization of atoms and dissociation of molecules. All these contribute to the biological action and for this reason it is necessary to consider the total energy transferred to matter rather than ionization alone. The unit employed is the linear energy transfer (sometimes referred to as the L.E.T.), which is the amount of energy transferred per unit length of path of the ionizing particles, usually measured in keV. per micron of tissue. This does not depend on the mass of the ionizing particle but only on its charge and velocity. The very marked variation with velocity explains the observed difference between the damaging action of alpha particles, protons and electrons, of the same energy. But although different particles with the same value for the linear energy transfer produce the same biological effect, the relationship between the linear energy transfer and biological damage, or the relative biological effectiveness (R.B.E.), is not at all straightforward. Prof. Rotblat quoted examples of biological processes, in some of which the biological damage increases with linear energy transfer, in others decreases with it, and in still others first increases and then decreases. These variations indicate the existence of different mechanisms of biological action.

Turning to the doses of ionizing radiations to which man is nowadays exposed, Prof. Rotblat made a survey of the natural background of radiation, pointing out that this will differ depending on whether one considers the gonad dose, the dose to bone or to other tissue. In Great Britain the gonad dose is 0·1 r. per year, or 3 r. in thirty years; the bone dose is slightly greater and amounts to 8·5 r. during seventy years of life. Of the man-made radiations, the largest contribution is from diagnostic radiological examination. The Medical Research Council report gave a figure of 22 per cent of the natural background, but more recent evidence indicates that the actual value may be 5–10 times higher, which would bring it in line with that in the United States. The fall-out from nuclear test explosions has up to now contributed very little so far as external radiations are concerned, but internal radiation gives rise to some concern. The effect of cæsium-137 in the body, although quite small, has perhaps been dismissed too lightly, but the concentration of strontium-90 in bone is the more worrying factor.

All these doses appear quite safe when compared with the maximum permissible dose (M.P.D.) established by the International Commission on Radiological Protection, which amounts to 0·3 r. per week, or 150 times the natural background. It has, however, to be remembered that the maximum permissible dose was set up for people occupationally exposed, and on the assumption that only a small fraction of the population is so exposed. For the whole population the figure may have to be reduced by a factor of 10 or even 50, but there may be other reasons for lowering the maximum permissible dose. It is now becoming evident that the doubling dose for leukæmia may be much less than was thought. Another factor, which came to light only recently, is the shortening of life-span due to an acceleration of the natural processes of ageing. A survey of radiologists in the United States, showing a reduction of life-span by five years, may be statistically uncertain, but there is no doubt about this effect from experiments on animals. These experiments show that every irradiation results in some irreparable damage, and that the lethal dose gradually decreases with age. If this is extrapolated to human beings, it leads to an inherent limit of life-span due to the natural background of radiations. This limit may be two hundred years or more, but the grim significance of this sort of speculation becomes apparent when applied to the present maximum permissible dose, which would reduce the life-span to about thirty years from the time exposure began. There seems, therefore, to be a good case for lowering the maximum permissible dose, quite apart from the genetic hazards.

Prof. Penrose opened his discussion of the biological damage due to radiations by directing attention to the ignorance there is of the intermediate steps in their action, stating that one could only

speculate with the knowledge available. He pointed out that the major damage to populations exposed to an atomic explosion would be due to heat and blast, and not to radiation. Ionizing radiations were, however, damaging even in small intensities. Their effects could be divided into immediate, during the first few weeks, and delayed. The immediate effects, such as burns and anæmia, are well known. Their relation to the dose received is not linear, lower doses producing apparently no effect. With the delayed effects, such as cataract or leukæmia, the picture is different. From the evidence on survivors at Hiroshima and Nagasaki, as well as from the findings of Court Brown and Doll on patients treated with X-rays for ankylosing spondylitis, it is clear that the incidence of leukæmia increases linearly with the dose. This linear relationship between exposure and delayed effects emerged towards the end of the Medical Research Council Committee's deliberations and was the reason for the demand for a reconsideration of the maximum permissible levels.

Another point to be clarified in the public mind is the difference between somatic and genetic effects. Direct damage to the fœtus by radiations has been studied on pregnant rats and mice as far back as 1931, and the findings have been supported by observations on human fœtuses. It was found that large doses to the mother's abdomen could clearly cause fœtal damage not previously suspected. Apart from miscarriage, this could result in the birth of babies with arrested development of the central nervous system leading to a special type of microcephaly. These risks, which had been known for some time, were definitely confirmed in the populations exposed at Hiroshima. Dr. Alice Stewart and her colleagues at Oxford claim to have observed delayed deleterious effects on the fœtuses exposed at any time during pregnancy to a much smaller dose of X-rays, such as occurs during diagnostic pelvic X-ray of the mother. In these offspring there was found to be a significantly higher incidence of leukæmia, which developed one, six, or even ten years after birth. Prof. Penrose hesitated to accept these findings as fully proved, but felt that although the damage occurred only in a small proportion of the mothers X-rayed in pregnancy, nevertheless it was important.

The genetic hazard can only be considered by looking at a long-term picture. There are two processes to be considered—chromosome breakage, which disturbs nuclear harmony, and point mutations, both of which may be the result of ionizing radiations. When a chromosome breakage occurs, both theory and experiment show that the effect is proportional to the square of the dose because, to produce an effect, there must be two breakages with the possibility of joining up again to reproduce. In the case of point mutations there is a direct linear effect, and this has been established by work with *Drosophila*. In man, such mutations are far more difficult to study, and this has in part produced the impression that the genetic hazard results only in an increase in the number of achondroplasic dwarfs. Actually, an increase in the rate of mutations will increase many other far more serious conditions. Referring to the nuclear test explosions, Prof. Penrose stated that the number of fresh mutants would be small and difficult to demonstrate, and in this sense only is it insignificant: counted over the whole population the number would certainly not be negligible.

Prof. Penrose then produced some evidence of the part played by radiation on the natural mutation-rate in man. One method is to study the incidence of diseases believed to arise by spontaneous mutation in relation to the ages of parents. For chondrodystrophy and acrocephalosyndactyly the age of the father, but not that of the mother, is strikingly high. This could be explained by assuming that the gene loci concerned were not very sensitive to radiation but mutated in response to other factors. For the most sensitive loci, mother's and father's age would both be only slightly raised, as seems to be the case in retinoblastoma neurofibromatosis and epiloia. Mongolism falls into a quite different group, its incidence increasing with an increasing maternal, but not paternal, age, and it is clearly not due to point mutation.

In answer to questions on the haphazard use of radioisotopes therapeutically and experimentally, both speakers stressed that nowadays every care is taken in the use of these materials. Prof. Rotblat explained that in the case of radioiodine therapy in thyroid disease, treatment is now limited to patients of the older age group where tumour induction after many years is of less importance than in the younger age group. Physicians in Britain have been more conservative in accepting the possession of a Geiger counter as essential for their practice than has the medical profession in the United States. The contribution from short-lived isotopes used in medicine has been calculated to be very small.

The chairman concluded the meeting by a revision of the old rules of health, suggesting that one should stay indoors to be shielded from cosmic rays, to stop drinking milk to limit the intake of cæsium-137, and to keep away from the doctor, to avoid being X-rayed.

P. J. Lindop

SIR VICTOR HORSLEY, F.R.S.

By Sir ARTHUR MACNALTY, K.C.B.

VICTOR ALEXANDER HADEN HORSLEY, neuro-surgeon, physiologist, pathologist and social reformer, was born on April 14, 1857. At the centenary of his birth it is appropriate to consider his scientific work, much of which was applied for the benefit of mankind.

Horsley achieved fame early. His brilliant career at University College Hospital, his personality, his exceptional intellectual powers, his devotion to professional work, his eloquence, forthrightness and rapidity of decision all bespoke genius. In 1880, while still a medical student, he published his first paper in *Brain* with H. C. Bastian on "Arrest of Development in the Left Upper Limb, in Association with an extremely Small Right Ascending Parietal Convolution". In 1882 (with F. W. Mott) he contributed a paper to the *Journal of Physiology* "On the Existence of Bacteria or their Antecedents in

Healthy Tissues"—then a controversial subject. He was associated with the research work of the Local Government Board, his paper on septic bacteria appearing as an appendix to the eleventh annual report of the Board in 1881.

In 1882 Horsley was appointed assistant professor of pathology in University College, London, becoming full professor from 1893 until 1896. In 1884 he was made professor-superintendent of the Brown Institution (University of London). During his six years of office at this Institution, in spite of his other duties as professor of pathology and hospital surgeon and the claims of private practice, he found time for an enormous amount of research work. He investigated the localization of function in the brain and the pathology of epilepsy and canine chorea. As the result of experiments on monkeys, his report on myxœdema in 1888 argued for the identity of myxœdema, cachexia strumipriva and allied diseases, and proved that these conditions were due to removal of the thyroid gland. As a surgeon he applied his laboratory results by transplanting the thyroid into patients suffering from myxœdema, and showed the treatment was specific. He thus founded the modern study of the thyroid gland in Great Britain and first suggested the rational method of treatment. In 1886 Horsley was not only the author of the report of the Local Government Board's Commission on Rabies which confirmed Pasteur's discovery of anti-rabic vaccine, but also the active investigator of the method both in Paris and at the Brown Institution.

It was as a neuro-physiologist that Horsley made his greatest contribution to science. In January 1884 he began with Prof. Schäfer in the Physiological Department of University College a series of researches on the brain of the monkey with a view of testing and, if possible, extending the work of Ferrier and Yeo on cerebral localization. Schäfer and Horsley confirmed Ferrier's results, and added to them with a finer analysis of certain groups of movements. With C. E. Beevor at the Brown Institution, Horsley further studied localization in a monkey both at the level of the surface of the brain and at the level of the nerve fibres passing from the surface of the brain towards the spinal cord; they also studied localization in the cerebral cortex of the orang-utan. In certain details these experiments have been corrected or modified by subsequent work, in particular by the more exact studies of Sherrington and Grünbaum; but Horsley's work marks a great step forward and made plain paths of research for others. In 1886 Horsley was elected a Fellow of the Royal Society, and in 1891, with Francis Gotch, he gave the Croonian Lecture to the Royal Society, "On the Mammalian Nervous System, its Functions and their Localization determined by an Electrical Method". He studied the motor innervation of the larynx with Sir Felix Semon.

In the closing years of Horsley's scientific researches he devoted special attention to work on the cerebellum, principally with R. H. Clarke. With special apparatus devised by Clarke, these investigators produced a minimal electrolytic lesion of a cerebellar nucleus without involving the cerebral cortex. This was the first use of electrolysis in cerebral physiology. Horsley and Clarke concluded that the cerebellar cortex is practically inexcitable; but this has been disproved by subsequent investigation with the use of a stronger electrical current. I had the privilege of assisting Horsley in his researches during 1904–9. The results of certain of these researches were incorporated in our joint paper in *Brain* (1909) entitled "Cervico–Spinal–Bulbar and Spino–Cerebellar Tracts and on the Question of Topographical Representation in the Cerebellum".

It has only been possible here to mention the chief of Sir Victor's researches. To describe them fully and to show their material contribution to neuro-physiology would need volumes. In addition, Horsley collaborated with many distinguished workers, and some publications under other names issued from his laboratory represent investigations guided and directed by him.

Neither is there space to mention his other interests. For example, his researches as a neuro-surgeon, which were the application of scientific physiology in the treatment of lesions of the brain and spinal cord, his work as a medical and social reformer and his political activities. Nor can I dwell here on his generous and noble nature, on the helping hand he stretched out to others, and his encouragement of younger men in scientific research.

In the end he died a hero's death from infection and heat-stroke on July 16, 1916, when he was reporting on medical conditions in Mesopotamia. It was his last crusade.

OBITUARIES

Sir John Townsend, F.R.S.

JOHN SEALY EDWARD TOWNSEND, who died in Oxford on February 16, at an age of eighty-eight, was one of the most notable physicists of his day, a master of experiment and theory alike and the founder of the kinetic theory of ions and electrons in feebly ionized gases. He was the son of Prof. Edward Townsend, of Queen's College, Galway, Ireland, and was born there on June 7, 1868. He was educated at Trinity College, Dublin, where he took a Moderatorship Examination in mathematics, mathematical physics and experimental science in 1890, and was a Fellowship Prizeman in 1893 and 1894. In 1895 he went to Cambridge, where he and Rutherford became J. J. Thomson's first research students. Later he was made a demonstrator in the Cavendish Laboratory and a Fellow of Trinity College and won the Clerk Maxwell Studentship. Among his contemporaries were also Larmor and Langevin. Townsend made his name with his work on the formation of electrically charged clouds, from which he derived for the first time a value of the elementary charge: he produced by electrolysis a charged gas which was then saturated with water vapour. By removing the latter with sulphuric acid, and weighing the acid, he obtained the mass of water in the cloud. From photographic recordings of the rate of fall of the cloud, he found the mass of a droplet in the cloud and this, together with its total charge, gave the ionic charge of a droplet as about 3×10^{-10} e.s.u.

When the University of Oxford decided to promote research in experimental physics on a larger scale,

Townsend was elected to the new Wykeham chair in 1900, together with a fellowship at New College, R. B. Clifton being the existing professor of experimental philosophy. Until means for a laboratory were found, Townsend worked in the Observatory and later in the University Museum. It was not until 1910 that, with the help of the Draper's Company, the Electrical Laboratory was built, a stone building with walls 3 ft. thick, which was specially designed for electric and magnetic research.

Townsend's early work included a study of solar disturbances, magnetization of liquids, and the effects of secondary X-rays; but very soon he turned his attention to the motion of swarms of electrons in gases, in particular their motion in electric and magnetic fields. He recognized very early that drifting electron swarms could be treated as a flow of a gas passing through another stationary gas. Later he developed the concept of a 'hot electron gas' which is driven by the electric field through the cold parent neutral gas, the average energy of the electrons being orders of magnitude higher than that of the neutral molecules. This is because the light electrons are able to transfer only a small fraction of their energy to the heavy molecules in collisions. He also showed that the ionic charge in a gas is the same as in a liquid electrolyte.

From his numerous outstanding contributions one recalls the first measurements of the drift velocity of electrons (with Lattey) and its more accurate determination by deflecting the electron swarm by a transverse magnetic field, of diffusion and random velocity of electrons in gases, and of the average energy losses which the electrons suffer in collisions with gas molecules (with Pidduck). To him also must be given the credit for the discovery of the dependence of the mean free path of electrons on the mean electron energy of swarms which he found in argon, now known as the Ramsauer–Townsend effect. He will be remembered for his fundamental work on the multiplication of charges by electron collisions and the dependence of the (Townsend) ionization coefficients on the electric field. He supported the first quantitative research by Kirkby on electro-chemistry of ionized gases. He showed that electrons and sometimes ions ionize gases, and that positive ions release secondary electrons from the negative electrode, thus increasing the current flowing through the gas until suddenly the gas becomes a good conductor and a spark crosses the gap. He investigated electric breakdown, developed similarity relations governing these processes and measured the emission of light from an electrically excited gas; continuous spectra of rare gases at high pressure were found early in his laboratory by McCallum. During his last years in office, he and Gill developed a theory of the electrodeless discharge in high-frequency electric fields.

Altogether Townsend published probably more than a hundred papers and several treatises: "Electricity in Gases" (1915), "Motion of Electrons in Gases" (based on a lecture which he delivered at the Franklin Institute in Philadelphia in 1925), "Electrons in Gases" (1947), "Electricity and Radio Transmission" (1943), and "Electromagnetic Waves" (1951).

Townsend was a man of great energy who took much interest in hunting and he had a great sense of humour. He loved talking shop, but still more loved to have an argument. Looking back at his scientific contributions, one wonders why he was not selected to receive more honours in the field of science. There are many possible reasons. He belonged to the rare class of men who are content and happy with their discoveries and their work. Moreover, his papers were not always easily readable. He seldom attended scientific meetings and took little interest in other people's fields. Although he was reluctant to advertize his or his research men's successes, it is quite remarkable that in spite of that, many of his school have achieved prominence—Moseley, Van de Graaff, Tizard, V. A. Bailey, L. G. H. Huxley, F. Llewellyn Jones and many others.

Townsend was a tireless worker and an excellent talker, but he was sometimes very absent-minded and stubborn. He once entered a dark room where he found a man struggling with an experiment. He told him how to perform it, took the readings for him and then left the room without being aware that the man was a candidate in a practical examination. During the First World War, King George V visited the Electrical Laboratory, where cadets of the Signals Corps were trained. At that moment Townsend was writing his *magnum opus*; he refused to be interrupted in his work, and was not presented.

Townsend was elected to the Royal Society in 1903, and later became a Chevalier de la Légion d'Honneur, a member of the Institute of France and a member of the Franklin Institute, and he was knighted in 1941. He married in 1911 Mary Georgiana, daughter of P. F. Lambert, of Castle Ellen, County Galway, with whom he spent a most happy home life and who survives him with two sons.

A. von Engel

Prof. V. F. Boldyrev

Vassilyi Fedorovich Boldyrev, who died in Moscow on February 25, was born in Saratov on January 20, 1883, educated at the Saratov Gymnasium and the University of Moscow, from which he graduated in 1906, when he joined the staff of the Department of Zoology and Entomology of the Moscow Agricultural Institute (now the Timiriazev Agricultural Academy), at first as an assistant, becoming professor in 1920. The Moscow Institute has been one of the main schools of agricultural entomology in Russia, where many workers in this field received their training, first under the late Prof. N. M. Kulagin, then Boldyrev. This school has always been characterized by giving a much wider general biological education to its students than is usually provided in a course of applied entomology; and Boldyrev has been, above all, an ardent and serious naturalist, able to inspire his pupils with the need to understand the living insects, rather than merely to learn how to kill them.

His own scientific work was extensive and varied. His main original contributions were in the painstaking studies of courtship behaviour and reproductive physiology of Orthoptera. His papers on the subject contain a vast amount of personal observations, described in a lively style rivalling that of Fabre. Other scientific works of Boldyrev dealt with the biology of various insects, while in the field of applied entomology he is deservedly known in the U.S.S.R. as the pioneer of the application of aircraft to the control of insect pests, particularly locusts. Those who, like myself, have been so fortunate as to know Boldyrev personally, will always remember his charming friendliness, deep love of living Nature and keen sense of very kindly humour.

B. P. Uvarov

NEWS and VIEWS

Physical Chemistry at the University of Birmingham : Prof. J. C. Robb

Dr. James C. Robb has been appointed, at the age of thirty-two years, to the chair of physical chemistry at Birmingham rendered vacant by Dr. H. W. Melville's appointment as secretary of the Department of Scientific and Industrial Research. Dr. Robb graduated from the University of Aberdeen with first-class honours in 1945. He was awarded the Carnegie Research Scholarship and later the Carnegie Senior Scholarship and gained his Ph.D. in 1948. He then moved to Birmingham with Prof. Melville, where he held a senior D.S.I.R. award (1948–50) and an Imperial Chemical Industries Fellowship (1950–51). He was appointed lecturer in chemistry in 1951 and senior lecturer in 1956. He gained his D.Sc. at Birmingham in 1954. He was appointed a member of the faculty board of mathematics and physical sciences in 1956. Dr. Robb has had a wide and varied lecturing and demonstrating experience and has assisted with the direction of many of Prof. Melville's researches concerning the reaction of free radicals in the gas and liquid phases. He has developed a solid source mass spectrometer and is interested in the application of this instrument and of gas phase chromatography as analytical tools. He will maintain the Birmingham tradition of discovering new techniques for studying the kinetics of reactions, including those concerned with polymerization. He is particularly interested in student activities, having formed and commanded a technical company of the Army Cadet Force in Aberdeen and having been an honorary vice-president of the University Athletic Union at Birmingham. Dr. Robb brings youth and energy to his chair at a time when the Chemistry Department in the University of Birmingham is undergoing considerable expansion.

Mining at the University of Sheffield : Dr. A. Roberts

Dr. Albert Roberts, who has recently been appointed director of the Postgraduate School of Mining in the University of Sheffield, was educated at the Wigan Junior Technical School and the Wigan Mining and Technical College, and graduated in mining in the University of London in 1932. Dr. Roberts received training as a mining engineer in the north of England, gaining a colliery manager's certificate ; he held various colliery appointments in Lancashire. In 1935 he was assistant manager at the Wigan Coal Corporation's Parsonage Colliery. Experience in metalliferous mining followed, with the Ashanti Goldfields Corporation, Ltd., during the course of which he travelled extensively in British and French West Africa, the Sahara and North Africa. He returned to England shortly before the outbreak of war, and since 1940 has been engaged in mining education and research, having successively held appointments as lecturer in mining and geology at Sunderland Technical College, mining organizer to the Shropshire Education Committee, and lecturer in mining at the University of Nottingham, where he was awarded the degree of Ph.D. in 1953. In January 1955 he was appointed senior lecturer in the Postgraduate School of Mining at the University of Sheffield.

Fundamental Research at the Mellon Institute

The Mellon Institute in Pittsburgh has adopted plans for a major expansion of fundamental research under the leadership of Paul J. Flory, executive director of research. It is widely recognized that, despite the funds available for the support of research in the United States, the progress of fundamental science has seriously fallen behind the proliferation and consequent requirements of applied science and technology. It has been decided, therefore, that the Mellon Institute can best perform the aims of its foundation in 1913 as a non-profit making institution dedicated to scientific research for the benefit of mankind by orienting its organization as a centre of advanced investigation, with comprehensive attention to fundamental problems. Although it is the aim eventually to direct the Institute's main efforts along the lines of research the object of which is the extension of the frontiers of knowledge, there is no intention to depart from the field of applied research. A healthy collaboration between fundamental and applied research will be fostered, and in applied research, investigations of a long-range character, or pioneering nature, will be especially encouraged. Fundamental research is contemplated in fields embracing physical chemistry, chemical physics, and inorganic, organic and analytical chemistry, with an emphasis on solid state physics, polymer chemistry and physics, radiation studies, and biophysics and biophysical chemistry. The importance of granting freedom commensurate with ability to individual research workers is recognized, and a wide latitude of opportunity will be assured for creative research. Members of the research staff will be encouraged to direct their efforts toward significant objectives of their own choosing, and to evolve their own problems and programmes.

British Hat and Allied Feltmakers Research Association

The ninth annual report of the Director of Research, British Hat and Allied Feltmakers Research Association, for the year ending August 1956 (pp. 23. Manchester, 1957), records no radical change in the research programme. A detailed study of the absorption of mercury by proteins from solutions of the metal in sulphuric acid indicates that reaction occurs on cystine and tyrosine groups, but that there is a more labile combination with other groups. Progress is reported with the comprehensive series of carrotting trials, and storing trials indicated the importance of temperature on the performance of the fur. Attempts to devise a simple laboratory test to assess the feltability of wool/noil blends and, in particular, to indicate damage, suggest that without rigid control of carding conditions, use of felting without complementary testing cannot be recommended as a means of assessing fibre damage. A further attempt was made to measure the influence of fibre-length on the rate of felting and an examination of the physical characteristics of felt made from fibres cut to 2-cm. and 8-cm. lengths showed that the tensile strength of the felt and the contribution of the fibre to the felt strength both decreased as the fibre-length increased. Considerable progress was made in studying the physical and chemical properties of shellac, and work on proofing was re-opened with particular reference to the effect of heat treatment on the stiffness produced. The work on wool hardening is now concerned with the mechanical transfer of energy from the

machine to the wool, while work on dyeing wool, raw fur and fur which has been carrotted, both with mercuric and with non-mercuric reagents, showed that the initial rate of dyeing was greater for wool than for fur, but that the final degree of exhaustion attained with fur and wool under comparable dyeing conditions did not differ significantly.

The Welsh Economic Development Council

In addressing the Trade Promotion Conference at Cardiff on October 12, 1956, Dr. Clyde Williams, president and director of the Battelle Institute, describing the development and use of science and technology by American industry and particularly the technological revolution which has occurred since 1940, said that in arriving at recommendations for area planning, teams at the Battelle Institute first made a detailed survey of all resources within the area that might bear on its economic development. They then proposed steps which the planning group should take, sometimes outlining programmes of research and development to exploit unusual situations. Dr. Williams suggested that the Welsh Economic Development Council should organize and conduct such a study, and in a memorandum issued on March 28, the Council urges the formation of a Welsh Water Resources Council to safeguard and promote the full development of Welsh water resources. Such a body would give valuable assistance to the advisory committee of the Minister of Housing and Local Government by collecting, assimilating and issuing reports on the hydrological cycle as a whole in Wales and by assisting with the provision of data essential for the water policy which is so vitally needed in Wales. The Council would provide the means of co-operation among Welsh water authorities but would not usurp their functions. The memorandum recommends consideration of the means of financing the full development of the water resources of Wales.

The University Women's Part-time Employment Agency

A register of graduate women in the London area who are prevented from taking on full-time work because of family responsibilities, but who would like to use their qualifications and experience in suitable part-time work, has recently been compiled by the University Women's Part-time Employment Agency and has already been found useful by employers in search of trained staff. Some women on the register take up outside work for part of each week and others are available for work such as abstracting, translation or proof-reading which can be done at home. Temporary as well as permanent work is undertaken, and some employers find the scheme particularly useful when a member of their permanent staff is ill or in 'rush' periods when extra help is needed. The type of work done includes translation, research, statistical analysis, indexing, typing and teaching. There are now about sixty science graduates on the register, many of them with experience of research in industry or for government departments. It is hoped that this Agency may help to ensure that such experience is not wasted. Further information can be obtained from Mrs. D. D. Furley, 57 Richmond Road, New Barnet, Herts.

The Electric Railway Society

With the growth of technology comes an increase in the number of specialist groups formed from those interested in the various fields: thus the recent emphasis upon railway electrification has led to the foundation of the Electric Railway Society, which caters for those interested, professionally or otherwise, in the study of electric railways. Its neatly duplicated *Journal*, published six times a year, shows the Society to be interested in the history, operation and even sociology of electric railways, as well as in their more obvious technical features. Further information about the Society and its publications may be obtained from the Secretary, 4 Sandhurst Road, Sidcup, Kent.

Technological Information in Britain

The Central Office of Information Reference Pamphlet No. 21 on "Technological Information in Britain" (pp. iii+36. London: H.M. Stationery Office, 1957. 2*s*. 6*d*. net) provides a brief account both of the Government's proposals for the expansion of technological and technical education in Britain (without, however, clearly distinguishing between them), and of the provision already made for training technologists and technicians. Some account is given of the professional institutions as well as of some fifteen establishments including—besides such institutions as the Imperial College of Science and Technology, the Royal College of Science and Technology, Glasgow, and the Manchester College of Science and Technology—the national colleges created to deal with particular fields of technology. A final section directs attention to the way in which the needs of overseas students in Britain and of British technologists overseas are met.

Public Libraries in Britain

A pamphlet on the Statistics of Public (Rate Supported) Libraries in Great Britain and Northern Ireland, 1955–56, issued by the Library Association (pp. 33. 7*s*. 6*d*. net), is in future to appear annually. It shows in tables, arranged alphabetically in one sequence of names of county and urban library authorities, the issues, stock, staff, income and expenditure of the 583 library authorities in the United Kingdom (including a few burghs in Scotland), whereof the statistics are included in the county library's return, apart from fifty libraries which did not reply to the questionnaire. Thirty-three of these served populations under 10,000 and it is unlikely that issues from these fifty libraries would total much more than 2,200,000. Adopting that figure, the grand total of lending library issues amounts to 398,730,000, an increase of 12,430,000 on the previous year. The percentage of non-fiction in adult issues was 29, and 127 libraries recorded more than 10 issues per head of population, 58 recording less than 5. The total stock in all British public libraries is estimated at about 63,400,000 volumes, and allowing for those libraries which made no return, expenditure is estimated at £13,870,000, of which 23 per cent was on books, 6 per cent on binding, 1·25 per cent on periodicals and newspapers, 42·5 per cent on salaries and 5·5 per cent on wages. The national average expenditure on books was 1*s*. 4*d*. per head of population, and of the libraries making returns only 41 per cent spent more than 2*s*. per head on books. The total number of registered readers returned was 11,689,696, and of full-time non-manual staff 12,700, full-time staff provision in the counties being 1 per 5,690 of the population and in the urban libraries 1 per 3,350. There are at least 31,957 public service points in the United Kingdom, comprising 573 municipal central libraries and county headquarters, 1,240 full-

time branches and 30,144 part-time branches, centres, etc., as well as 185 mobile libraries.

Scientific Bibliography for the Middle East

THE National Research Council of Egypt, Cairo, is issuing, as a continuation of the "List of Scientific Papers published in the Middle East", abstracts of scientific and technical papers published in Egypt and papers received from Afghanistan, Cyprus, Iran, Iraq, Lebanon, Pakistan, Sudan and Syria, of which Nos. 3 and 4, Vol. 1 (October and December 1955), have already appeared. The abstracts are classified under pure and applied mathematics; astronomy and geophysics; physics; pure and applied chemistry; geological sciences; biological sciences; medical sciences; engineering; agriculture and veterinary sciences, with sub-divisions as required; and there are author and subject indexes. The first four issues have been distributed free for publicity purposes, but beginning with No. 1, Vol. 2 (January 1956), the *Bulletin* is being published monthly and distributed regularly only by subscription or in exchange for other scientific publications. Applications should be made to the Director of the Scientific and Technical Documentation Centre, National Research Council of Egypt, Dokki, Cairo.

London Computer Group: Regional Centres

THE London Computer Group has now completed arrangements to assist in the formation of other similar groups of members outside the London area. These groups will share common services, but retain their local autonomy and individuality. The regional centres are intended to fulfil the same objects as the London Computer Group—the creation of opportunities for specialists in many fields, with some interest in the design, manufacture and use of electronic computers and data processing equipment, to meet together, as individuals and not at an official level, for the discussion of common problems and the exchange of knowledge and experience. Further details may be obtained from the Hon. Secretaries to the Group at 29 Bury Street, St. James's, London, S.W.1.

The London Computer Group is also setting up a Research Sub-Committee to report on specific problems addressed to it from time to time, and in particular to maintain the annual survey of computers and electronic data processing installations operating and planned in Britain.

Veterinary Science in Australia

THE wide scope of modern veterinary science, its relations with agriculture on one hand and with medicine on the other, the opportunities it offers to young men and its achievements in Australia in spite of continuing shortage of veterinarians in that country, were all discussed by Prof. John Francis, dean of the Faculty of Veterinary Science of the University of Queensland, in a recent address given at the ceremony of conferring degrees at that University. Australia has only 800 veterinarians, while Great Britain has 6,000; and Queensland's most valuable animals, sheep and beef cattle, lack almost completely the kind of veterinary services available elsewhere. The Veterinary School in Queensland is, as Prof. Francis explained, doing all it can to remedy this state of affairs. Dr. G. R. Moule, director of the sheep and wool branch of the Division of Animal Industry, who has done distinguished work in this field, is the first person on whom the University of Queensland has conferred the degree of doctor of veterinary science.

Colonel Lionel Rose, chief veterinary officer of the Northern Territory, has rendered valuable service to the cattle industry of that area. Many of the worst animal diseases have been eradicated, and problems of nutrition and animal management have been energetically studied. A great deal, however, remains to be done, and the Veterinary School of the University of Queensland is energetically tackling the problem of the shortage of veterinarians. Prof. Francis outlined the courses of training given, the achievements of the graduates of the School and the development of the University's Farm at Moggill, situated on land given by Dr. Maine and helped by grants from Australian banks and by Mrs. S. M. Thomson of Worthing; a new veterinary school at St. Lucia is also being built about four miles from the farm.

The Australian Museum

To promote more interest in its *Magazine*, the Australian Museum has decided to seek more articles from outside contributors, to include articles on plant life and to publish each December an issue dealing authoritatively with a special topic. For the first special issue the subject is "Australia" (12, No. 4; December 15, 1956). Among the articles is one by Charles F. Laseron describing the nine different geological periods when the sea covered some part of Australia. Winifred M. Curtis describes the flowering plants of Australia, special attention being paid to such peculiar Australian species as *Eucalyptus*, she-oaks (*Casuarina* sp.), *Hakea*, *Bantisia* and the waratah, *Telopea*. Another article deals with Australian mammals and is illustrated with some remarkable photographs of young bandicoots feeding. The well-known Australian birds, the lyre-bird, bower-bird, kooka-burra, emu and cassowary are described and illustrated, as are more typical Australian insects. The Great Barrier Reef and its corals, by W. Stephenson, forms one of the most interesting articles in the journal.

The South African Museum

IN the one hundred and first annual report of the South African Museum for the year ending March 31, 1956 (Cape Town: South African Museum, 1956), the Trustees recall with pride the history of that institution which from small beginnings has grown into a scientific organization of international repute. The centenary was celebrated by the unveiling of a memorial plaque by Mr. J. H. Viljoen, Minister of Education, Arts and Science, and a special display illustrating the growth of the Museum and the scope of its activities. Under a new Act of 1954 which repeals the South African Museum Act of 1857, a new Board of Trustees has been appointed. The Trustees consider that the change from a simple trust autonomy to a more complex administration has been accomplished without undue inconvenience but admit that the increase in clerical work threatens to curtail the Director's time for research and scientific work. In the galleries considerable progress has been made with the construction of a new series of dioramas showing present-day reptiles and amphibians.

International Implications of Nuclear Power

AN article, "Atomic Power", by the technical editor of the "International Year Book and States-

man's Who's Who" has been reprinted from the current edition of the "Year Book" (pp. 8. London: Burke's Peerage, Ltd., 1957). Emphasizing the vital importance of the development of nuclear energy to Britain and the Commonwealth, it reviews recent developments both in production and in research, pointing out the difficulty of solving any technical or economic problem in the nuclear field except within a global framework. Britain, the United States and the U.S.S.R. are not the only nations concerned. Belgium's uranium resources place her in a special position in connexion with nuclear research and development. It is particularly significant for Great Britain that in the less-developed regions coal, oil and water will remain vital sources of power, but in territories where technology is highly advanced they will rapidly become obsolete. It is in the distribution of isotopes that Great Britain is making its most significant contribution to the undeveloped areas. In conclusion, the article points out that in spite of its limitations, the United Nations provides a common forum; indeed the only one equipped to formulate policies upon which could be built a united nuclear world.

Observations of Atmospheric Waves by Radio-sonde

It is now well known that when wind increases with height and the air is convectively stable, regular ascending and descending movements, similar to the waves set up in a river flowing over a weir, may occur on the lee-side of mountains. The existence of such waves was recognized first from clouds and later from their effects on aircraft. No systematic observations of them have hitherto been possible; data have depended on seeing clouds of the particular type associated with the waves or on chance encounters of the waves by aircraft. Now Mr. G. A. Corby has shown (*Quart. J. Roy. Meteor. Soc.*, **83**, 49; 1957) that the waves can be observed with the radio-sonde. This instrument transmits observations of pressure and temperature at regular intervals as the balloon to which it is attached rises through the air.

The curves of pressure against time recorded during 1,440 ascents at four British radio-sonde stations between November 1953 and April 1954 were examined and a number were found on which the rate of ascent of the balloon clearly varied systematically. During 48 of the ascents the vertical speed of the balloon varied systematically by more than 300 ft./min. and there was no evidence, such as the presence of cumulus clouds, of the likelihood of the existence of any appreciable vertical currents not due to waves or of precipitation which might have affected the rate of ascent of the balloon. The paper contains a number of curves of the vertical air currents in terms of the height of the balloon which show clear wave-like up and down currents. There is confirmation in the shape of reports by pilots of civil aircraft arriving at Northolt for about half the occasions. Special interest attaches to the waves recorded by radio-sonde ascents on April 14, 1954, when vertical currents approaching 1,000 ft./min. were recorded near Leuchars (Fife) and aircraft reported currents of up to 1,900 ft./min. in the Edinburgh region. Statistical examination shows that the average horizontal wave-length of the 26 cases with a dominant wave-length was 6·7 miles with extremes of 2·6 and 14·4 miles. The wave-length increases with wind speed as would be expected from the general theory of lee-waves. Mr. Corby concludes by pointing out that it might be profitable to investigate wave-effects in mountainous areas with a mobile radio-sonde station. Such work might, apart from the purely scientific interest, be a contribution to aircraft safety.

Determination of Moisture in Solids

A knowledge of the moisture content of many non-metallic solids is required for purposes connected with their production, sale, use or storage. Examples of such materials are textiles, crops, foodstuffs, paper and board, wood, ceramics, plastics, building materials, electrical insulating materials, soil in agriculture and civil engineering, moulding sand, chemicals, solid fuels and biological substances. In 1955, the Laboratory Apparatus, Thermometers and Thermostats Research Panel of the British Scientific Instrument Research Association recommended that a survey be made of methods of measuring the moisture content of solids, and the results of that survey by P. J. Geary have now been published (British Scientific Instrument Research Association. Research Report M.24: Determination of Moisture in Solids: a Short Survey of Methods and Apparatus. By P. J. Geary. Pp. iv+52. Chislehurst: British Scientific Instrument Research Association, 1956. 7*s*. 6*d*.; overseas purchasers, 9*s*. 6*d*.). Methods for determining the amount of moisture are described briefly, and equipment suitable for the determination which is available commercially in Great Britain is listed. Brief notes are given of about forty different methods and 247 selected references, and particulars of fifty-three manufactured equipments are included. The methods of determining moisture content of a solid, that is, the percentage by weight of water present in the material, fall into two groups, one consisting of those in which the water in the material is disturbed, and the other of those in which the water is not disturbed. The latter group includes methods which are dependent on a physical property of the material (for example, specific heat, thermal conductivity or reflexion of light) affected by its moisture content, and two fundamentally new techniques, utilizing neutron scatter by the hydrogen nuclei of the contained moisture and nuclear magnetic resonance of the hydrogen nuclei. None of the apparatus mentioned has been examined or tested by the Association and no attempt has been made in the survey to quote accuracies or determination times, which can vary considerably according to the circumstances.

Mathematical Printing

The need for skilled mathematical printing increases with the growth of mathematics and the widening of its domain of applications; to help to meet this need, authors should understand something of the compositor's problems, and compositors must have some special knowledge of mathematical requirements. The author seeking such instruction will find all he requires in "The Printing of Mathematics", by Chaundy, Barrett and Batey (Oxford, 1954). For the compositor, the *Monotype Recorder* (40, No. 4, 1956) consists of an essay by Mr. Arthur Phillips on "Setting Mathematics", a concise and informative account of the needs of the mathematician and the ways in which the compositor must be prepared to meet them. Many illustrations of good and bad setting are given; these should be studied by author as well as compositor, and a closer co-operation based on such study might contribute substantially to a reduction in the cost of mathe-

matical printing. A note on the experimental four-line mathematical system for dealing with formulæ, estimated to save about 20 per cent in the time of setting, is accompanied by a typical page prepared by this method. It is clean, attractive and not unduly cramped, though not entirely satisfactory in its handling of the tiresome but frequently occurring index which itself carries a suffix.

A New Organophosphorus Insecticide

During the past twelve years a succession of organic phosphorus insecticides have been brought into commercial use. Schradan, parathion, systox and others are well-known substances. They are exceedingly toxic to insects and some of them act as 'systemic' poisons: entering the sap stream of the plant, they are carried into all its parts, rendering the foliage poisonous to insects that feed upon it. The most widely used of these materials in orchards has been parathion. But like most members of the group, this is highly poisonous to man and therefore needs the greatest care in its application; and it is destructive to the beneficial predators, so that when used against the fruit tree red spider mite its immediate good effect is liable to be followed by an extensive build-up of the pest later in the season. Plant Protection, Ltd., has now announced the production of a new chemical, O,O-diethyl-S-(beta diethylamino) ethyl phosphorothiolate hydrogen oxalate, which is being marketed under the trade name of 'Tetram' or 'I.C.I. amiton'. This substance again has a high toxicity to man, but as an insecticide it is claimed to be largely specific for red spider and other mites and for scale insects, and to have little effect on insect predators, so that the adverse after-effects of parathion do not occur. 'Tetram' is systemic in its action, said to be effective at a dosage of two ounces per acre and to be so persistent that a single application in the season is effective. So far it has been tested on a large scale chiefly against cotton-, citrus- and apple-infesting mites and scale insects. Permission to sell 'Tetram' in most countries will be obtained later in 1957; supplies will be available to fruit-growers in Britain this season.

Forestry in Africa

The annual report for 1955 of the Forest Department of the Uganda Protectorate (pp. vi+65. Entebbe: Government Printer, 1956. Shs. 3/25) states in a foreword that the responsibility for the provision of forestry services in Uganda is shared between the Protectorate Government and local authorities. The Central Forest Reserves are under the former, whereas the Buganda Government and other local governments are responsible for the management of forest reserves serving local needs. The division is somewhat unusual but appears to be working well. Advisory, educational and research services are under the Central Government. Under sylviculture, the natural regeneration of high forest was continued, and the creation of 459 acres of new softwood plantations now brings the total of these to 2,903 acres. Both the Forest Department and the local governments have under their charge considerable areas of fuel and pole plantations, important equally for neighbouring big towns and for the people in the countryside. There are 12,000 acres under Government control and 8,000 acres under local authorities. The sylvicultural research plan has been expanded and the utilization research plan has been completed and approved.

For the northern region of Nigeria the annual forest report for 1954–55 (pp. ii+31. Lagos: Government Printer; London: Crown Agents for Oversea Governments and Administrations, 1956. 9*d*. net) records a year of solid and unspectacular progress. The northern part of Nigeria has been neglected in the past from the forestry point of view and the Forestry Department is still in the making. The chief energies of the Department are at present concentrated in reserving areas of State forests to be managed in the interests of the country. The public, however, are taking little interest in forestry, and, in contrast with Uganda, local villages are reluctant to maintain their own communal fuel areas which had been formed for them in order to free the forest reserves from these demands. Notes are being made of the types and conditions of the forest as the new reserves are selected. In this connexion unexpected assistance has been obtained from aerial photographs obtained from the Directorate of Colonial Surveys; although they are on a small scale they are proving very useful.

Overseas Service Division: Colonial Office

The following appointments have recently been made in the Overseas Service Division of the Colonial Office: W. R. Asfour (agricultural superintendent, British Guiana), agricultural economist, British Guiana; H. K. Ashby (senior agricultural officer, grade *A*, Federation of Malaya), assistant director of agriculture (field), Federation of Malaya; A. L. Barcroft (agricultural officer, Federation of Malaya), senior agricultural officer, grade *B*, Federation of Malaya; P. A. Chang-Choong (economic botanist, British Guiana), assistant director of agriculture (field and extension), British Guiana; J. K. Coulter (senior research officer, grade *B*, Federation of Malaya), senior research officer, grade *A*, Federation of Malaya; R. Henderson (senior agricultural officer, grade *B*, Federation of Malaya), senior agricultural officer, grade *A*, Federation of Malaya; H. J. Simpson (assistant director of agriculture (field), Federation of Malaya), deputy director of agriculture, Federation of Malaya; G. E. Crichton (senior assistant conservator of forests, Sierra Leone), working plans officer, Nyasaland; J. Mitchell (geologist, Geological Survey Department, Ghana), senior geologist, Geological Survey Department, Ghana; J. M. S. Garrod (leprosy specialist, Northern Rhodesia), director, East African Leprosy Research Centre, East Africa High Commission; W. M. Fitzsimmons (veterinary officer, Swaziland), veterinary research officer, Nyasaland; I. R. Grimwood (biologist, Department of Game and Tsetse Control, Northern Rhodesia), assistant director, Department of Game and Tsetse Control, Northern Rhodesia; J. W. Blencowe, temporary senior plant pathologist, West African Cacao Research Institute; P. Johnsen, entomologist (tsetse), Northern Rhodesia; J. A. McFarlane, scientific officer (stored products entomologist), Jamaica; H. MacNeill, survey assistant, grade I, Forests Department, Kenya; G. J. Snowball, technical records officer, Geological Survey, Northern Rhodesia; M. V. Christensen, temporary surveyor, Northern Nigeria; V. Jacobsen, surveyor, Federation of Nigeria; K. N. Toms, surveyor, Northern Nigeria; D. L. Stewart, veterinary officer, Uganda; A. Zatwarnicki, veterinary officer, Eastern Nigeria.

The Biological Council

At its meeting on March 20, the Biological Council elected Prof. J. F. Danielli as its honorary treasurer and Dr. L. Broadbent as its honorary secretary. Two societies, the British Herpetological Society and the British Society for Immunology, were accepted for affiliation to the Council, bringing the number of affiliated societies up to twenty-five.

The Queen's University of Belfast: Appointments

The following appointments in The Queen's University of Belfast are announced: Dr. J. R. Beloff, to a lectureship in psychology; W. E. Coey, to a lectureship in crop and animal husbandry; Dr. W. T. E. McCaughey, to a lectureship in applied pathology; T. R. F. Nonweiler, to a senior lectureship in aeronautical engineering; Dr. E. M. Pantelouris, to a lectureship in zoology; Dr. D. C. J. Burgess, to a lectureship in pure mathematics.

University of Leeds: Appointments

The following appointments in the University of Leeds are announced: the title and status of reader have been conferred upon Dr. R. S. Bradley, senior lecturer in the Department of Inorganic and Structural Chemistry; and the title and status of reader in mathematical chemistry have been conferred upon Dr. D. W. J. Cruickshank, lecturer in mathematical chemistry in the same Department.

Announcements

Mr. H. Williamson, formerly assistant to the director of the Division of Applied Biology of the National Research Council of Canada, has been appointed scientific liaison officer for the National Research Council in Washington, D.C. In co-operation with the Department of External Affairs, he will act as scientific attaché at the Embassy. Mr. Williamson replaces Dr. J. D. Babbitt, who was transferred to Ottawa to serve as assistant director (Information Services) in the Division of Administration of the National Research Council.

Mr. P. O. Wolf, lecturer in civil engineering at the Imperial College of Science and Technology, has been appointed to the university readership in hydrology tenable at that College.

Prof. J. B. S. Haldane will deliver the fourth Bateson Lecture at 5 p.m. on July 19 in the Library of the John Innes Horticultural Institution. The subject of his address will be "The Theory of Evolution, before and after Bateson". Inquiries should be made to the Registrar, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts.

The Heald Green Laboratories of the British Rayon Research Association at Wythenshawe, Manchester, will be open to visitors on May 9 and 10.

The Fulmer Research Institute is to hold an open day on July 2 to mark the tenth anniversary of the opening of its laboratories at Stoke Poges, Buckinghamshire. On that day the laboratories will be available for inspection, and some aspects of the work of the Institute will be exhibited.

The Cortina–Ulisse European Prize of one million lire (about £570), which is awarded annually by the magazine *Ulisse*, is being offered this year for a work of popular science on the possible peaceful applications of atomic energy. Only original works printed for the first time in Europe during the past five years will be eligible. Works published in a language other than Italian, French, German, English or Spanish must be accompanied by a translation into one of those languages. Five copies should be sent, before May 31, either by the author or by the publisher, to the Editor of *Ulisse*, Sezione Premio Europeo Cortina Ulisse, Corso d'Italia 43, Rome.

The new Division of Inorganic Chemistry of the American Chemical Society is seeking more members among scientists both in and outside the United States who are interested in inorganic chemistry. The membership subscription of 3 dollars a year may be sent to Dr. L. B. Asprey, Los Alamos Scientific Laboratory, Box 1663, Los Alamos, New Mexico. Dr. Asprey will also receive papers for presentation before the Division at the National Meeting of the Society to be held during September 8–13, in New York. Symposia are being organized on "New Industrial Inorganic Chemicals" and "High Temperature Inorganic Chemistry". The Division will also jointly sponsor a symposium with the Division of Physical and Inorganic Chemistry on "The Metal–Carbon Bond".

The Chemical Society has arranged a meeting in Glasgow on "Recent Advances in the Chemistry of Terpenoid Compounds" during July 11–12. Further details can be obtained from the General Secretary, Chemical Society, Burlington House, London, W.1.

The European Molecular Spectroscopy Group will be holding a meeting this year at the University of Freiburg im Breisgau, Germany, during July 9–13. A wide range of topics in molecular spectroscopy will be discussed. Information about attendance at the meeting and the presentation of papers can be obtained from Prof. R. Mecke, Institute of Physical Chemistry, University of Freiburg im Breisgau.

The fifth general assembly of the Società Italiana di Geofisica e Meteorologia is to be held in Genoa during April 23–25. Immediately afterwards, on April 26, the Centre International de Recherches sur la Météorologie de la Méditerranée is to hold a meeting in the Istituto Geofisico, University of Genoa, in order to decide on future research programmes and the necessary financial arrangements. Further details can be obtained from the Secretariat, Istituto Geofisico, via Balbi 30, Genova.

The annual Convention of the British Institution of Radio Engineers will be held in Cambridge during June 27–July 1. The third Clerk Maxwell Memorial Lecture will be delivered during the Convention by Sir Lawrence Bragg, director of the Davy-Faraday Laboratory of the Royal Institution, who will speak on the diffraction of short electro-magnetic waves. Further information can be obtained from the General Secretary, British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1.

The British Institution of Radio Engineers has arranged a convention on "Electronics in Automation", to be held in the University of Cambridge during June 27–July 1. Thirty papers are to be presented in six sessions on: office machinery and information processing; machine tool control; chemical and other processes; simulators; automation in the electronics industry; and automatic measurement and inspection. Further information may be obtained from the Institution's offices, 9 Bedford Square, London, W.C.1.

CROP ECOLOGY AND PLANT BREEDING FOR DISEASE RESISTANCE

SINCE its first meeting in 1951 the conference of plant breeders in East Africa has increased greatly in scope and stature. This change is a reflexion of its official title: Specialist Committee on Agricultural Botany. Although breeders and pathologists predominate, attendance at the recent meeting included physiologists, ecologists and other workers associated with crop research in Kenya, Uganda and Tanganyika. Throughout this formative period the Committee has been stimulated and guided by the chairmanship of Sir Joseph Hutchinson, director of the Cotton Research Station, Namulonge, who is shortly to take over the Drapers professorship in agriculture at Cambridge. This Committee is now an established part of inter-territorial co-ordination of agricultural research and, as such, provides a valuable forum for discussion and the initiation of policy on problems of plant breeding, pathology and crop research.

On January 22 and 23 the Specialist Committee met for the sixth time, the meeting being held at the headquarters of the East African Agriculture and Forestry Research Organization (Muguga, Kenya) at the invitation of the director, Dr. E. W. Russell. Some forty people attended, representing the Departments of Agriculture of the three territories, the Empire Cotton Growing Corporation, the Tanganyika Agricultural Corporation and the East African Agriculture and Forestry Research Organization itself. Visitors from certain other organizations and from other countries were also present.

The meeting took the form of talks by individual research workers followed by informal discussion; the two main topics were crop ecology and breeding for disease resistance. In the first of these, Dr. M. A. Keay (Makerere College) reviewed the need for direct observation to replace preconceptions and inferences from gross vegetational studies, as the basis for sound planning and advice. H. L. Manning and H. G. Farbrother explained their study of leaf area expansion and water losses in cotton crops, from which it had been possible to phase cropping to coincide with the greatest expectation of satisfactory rainfall. The correlation of rainfall with maize yields in western Kenya was described by J. Glover; the optimum rainfall had been deduced and actual yields could now be predicted. In the case of water studies in coffee, Dr. H. C. Pereira explained that there were special advantages arising from the perennial deep-rooting habit of the crop and the high water-storage capacity of East African coffee soils. In the general discussion which followed, the main conclusion was that a greater degree of direct observation was now needed in crop ecology, but that it was already a great advance to be able to discuss the water balances of individual crops, water being the limiting factor over most of East Africa.

In discussing breeding for disease resistance, Dr. G. M. Wickens used the contribution of plant pathology in cotton breeding to illustrate the essential need for a research pathologist in breeding projects. The particular difficulties recently encountered in breeding for stem rust resistance in wheat in Kenya were then described by H. C. Thorpe, the main trouble being the lack of fundamental knowledge of the pathogen and the mode of origin of new races. Coffee rust and the work of the special rust research station at Lisbon were reviewed by R. W. Rayner. The status in East Africa of tropical maize rust was described by Dr. H. H. Storey, who showed how research and breeding initiated before the disease reached East Africa had provided local maize with resistant genes obtained from Central America. The role of chemistry in disease control was briefly reviewed by Prof. R. L. Wain, of Wye College (University of London). Discussion followed, from which the most important conclusion reached was the need to seek the highest level of disease resistance since moderate resistance could apparently be overcome more easily.

Other subjects discussed were the need for increased physiological research on coffee, difficulties over ratoon stunting in sugar cane, policy in work on cassava, and the co-operative maize trials in the three territories. Between sessions the visitors toured the laboratories at Muguga and met other members of the staff of the East African Agriculture and Forestry Research Organization. The close of the meeting was marked by a special tribute to the chairmanship of Sir Joseph Hutchinson and his work for agricultural research in East Africa, and by the good wishes of all those present for his impending move to Cambridge. The Committee will miss him, but it may indeed be said that the Committee has 'come of age'.

G. E. DIXON

THE METEOROLOGICAL OFFICE

REPORT FOR 1955–56

THE appearance of the annual report of the Meteorological Office* is a noteworthy event. Several indexes, for example, the circulation of such journals as *Weather*, show that there is now a considerable informed public ready to take an interest in what three thousand of our citizens do with three million pounds—slightly less than 0·1 per cent of Britain's annual budget—to provide one of the most essential services of a modern State. In sixty pages there is abundant food for thought for any who are concerned with the relation between the functions of a government and the maintenance of a technical-scientific organization. Scientists will ask for evidence of that liveliness of mind and productivity in original research which will ensure that such a service is not likely to lapse into a care-and-maintenance organization with correspondingly limited duties and responsibilities. This annual report will not disappoint them.

* Annual Report of the Director of the Meteorological Office for the year April 1, 1955, to March 31, 1956. Pp. 60+4 plates. (London: H.M. Stationery Office, 1956.) 3s. 6d. net.

To an increasing extent a modern government finds itself the employer of a cadre of scientists over an ever-widening field. In the establishment of officers such as the Master of the Ordnance of Tudor times, the Astronomer Royal in 1675, the Director of the Geological Survey in 1835, we trace the growing needs. This annual report reminds us that in 1955 the Meteorological Office celebrated the centenary of its foundation under the Board of Trade. For long, however, there was a tendency to regard the universities and scientific societies as the fount of research in meteorology, a state of affairs which was dispelled at an earlier date in some other sciences such as geology. Therein the interchange of ideas stemming from the researches of the officers of the Survey and the holders of university appointments has for many decades proved fruitful.

In meteorology the same could scarcely be said, for far too little attention to the subject was given by the universities, and a count of chairs shows that even to-day there is much room for improvement. Before 1900 the Royal Meteorological Society was very largely composed of amateurs with other means of livelihood; and at the same time the Meteorological Office, with its small staff and extremely limited resources, could give but little opportunity for research. The more praise should be given to that small group who, fifty years ago, were advancing the subject. Some of them are still with us, and will be among the first to appreciate the wonderful opportunities the Office now provides for those who choose to study, after the manner of Shaw, the air and its ways.

The development of air transport has emphasized the need for knowledge of the vagaries of the tenuous yet formidably complex gaseous envelope in which we not only live but also move with ever-increasing speed; a speed demanding a corresponding acceleration of the rate of growth of knowledge, and a rate of publication which appears now to follow an exponential law.

This annual report provides cheering evidence that under the present director and his twenty-four senior officers the Meteorological Office is valiantly maintaining a remarkable level of activity, not merely in the upkeep of essential services—among which we can still include the ancestral photographic thermograph at Kew, in continuous operation since 1868—but also in research. This is perhaps the most inspiring note in the report. In spite of the heavy and incessant pressure of the endless routine demands, and the occasional ill-informed criticism of those whose efforts to forecast the behaviour of a fluid of changeable qualities in turbulent motion cannot always take account of all the variables, the Office is doing much to fulfil some of the functions which the universities have tended for one reason or another to neglect. For it remains an astonishing fact that established posts in meteorology are named in the calendar of but five British universities. Even if a few ostensible practitioners of other subjects spare a little energy for the study of the behaviour of the atmosphere, this cannot be enough. Moreover, the Meteorological Office has taken on much of the burden of research in a way which cannot but provide an encouragement to its own personnel; the stimulus to be found in the team-spirit of a lively university department of physics.

To what extent this is a consequence of the times, with its concentration of funds and expensive equipment under Government control, and how much is due to the inspiring example of Sir Graham Sutton and the many senior officers who kept the flag flying in the lean years between the wars, it would not be easy to say. Suffice it to direct attention to the remarkable range of activities comprehended among the three thousand staff. The clamorous battery of teleprinters flooding the observations hour by hour into Dunstable; the electronic computation devices now being developed to cope with this staggering assemblage of material; and the enormous range of the demand for specialized types of forecasts are associated with but one branch, even if some still think that the Office exists for little else than the day-to-day estimate of the behaviour of the next depression. There are now twenty-one branches (what has happened to M.O.5 ?) to deal with other problems. The cutting-down of the lag associated with the temperature readings transmitted by a radio-sonde; the measurement of light-intensity; the chances of easterly squalls on the airfields of Nigeria; the probable catch of water in a Highland valley devoid of rain-gauges; an admirable library service; and the generous advice and assistance with instrumental equipment for the young leaders of enterprising expeditions are but a few of the ways in which the advancement of science is stimulated. Moreover, commercial firms benefit enormously, and very cheaply, from this quiet and unostentatious public service: that, too, is a matter deserving of thought. Lastly, research is now being promulgated within university departments with the aid of grants from the Meteorological Office. This annual report gives a very cheerful impression of the developing relationship between the various institutions responsible for our national scientific accomplishment; and a subtle and enlivening touch is added in the list of papers and articles which the staff of the Office have themselves produced. It makes good reading, and scientists everywhere will extend their congratulations.

Gordon Manley

THE NATIONAL SCIENCE FOUNDATION

SIXTH ANNUAL REPORT

THE sixth annual report* of the National Science Foundation, covering the year ended June 30, 1956, in the main follows the pattern of the last two reports. The chairman's foreword is now accompanied by a statement from the director, Dr. A. T. Waterman, which, stressing the grave shortage of scientists and engineers and the need for fundamental research as well as for better general equipment for research, suggests that the most urgent task is to create an awareness and understanding in the citizens of the United States of the fundamental and critical nature of these problems. Dr. A. T. Waterman's report is again in two parts, but between his review of recent developments affecting the scientific community and his survey of the Foundation's own activities during the year, there is a photographic sample of those activities. Appendixes again occupying almost half the report list the personnel of the Board, advisory panels and committees of the Foundation, the basic research grants and fellowships

* National Science Foundation. Sixth Annual Report for the Fiscal Year ended June 30, 1956. Pp. xvii+189. (U.S. Government Printing Office, Washington 25, D.C.) 75 cents.

awarded during the year, the publications of the Foundation and include the financial report.

During the year the Foundation made 734 grants, totalling 9,655,205 dollars, to 258 institutions for the support of basic scientific research. Of these, 426 totalling 5,124,530 dollars were in the biological and medical sciences, and 308, totalling 4,530,875 dollars, in the mathematical, physical and engineering sciences. The average grant supports one or two graduate research assistants and frequently a post-doctoral research associate, so that during the year the Foundation assured opportunities for nearly 2,000 men and women to continue their scientific education in university laboratories. In the regulatory biology programme almost all phases of physiology and the more physiological aspects of biochemistry were represented. In the molecular biology programme grants were mainly in the field of protein and enzyme structure, while in genetics and developmental biology the emphasis was on transduction. Inquiries into the neurophysiology of learning received further support. In chemistry, research in the organic and physical fields predominated, and in the earth sciences programme, geochemistry received major support. In the engineering sciences programme the emphasis was in the fields of mass transfer, mechanics, thermodynamics, electrical circuits and electronics, fluid mechanics and physical metallurgy. The physics programme reflected increased interest in atomic and molecular structure.

During the year the Foundation submitted to Congress its first significant request for funds for the improvement of research facilities. It recommended provision of Federal funds for construction or purchase of large-scale facilities and major equipment for scientific research, including research centres, and during the year allocated 4 million dollars for the construction of a radio-telescope in Greenbank, West Virginia, and 545,000 dollars to the University of Michigan to support continuing studies of sites and equipment for an optical astronomical observatory for the south-west. A grant of 500,000 dollars was made towards the construction of a nuclear reactor at the Massachusetts Institute of Technology, and a first series of grants in support of computation centres and research in numerical analysis included 38,000 dollars to the Californian Institute of Technology, 30,000 dollars each to the Massachusetts Institute of Technology and the University of Wisconsin, 20,000 dollars to Oregon State College and 17,500 dollars to the University of Washington. For the support of biological field stations the Foundation allocated 750,000 dollars.

The man-power report is concerned especially with the improvement of the teaching of science, and during the summer of 1956 the Foundation sponsored twenty-five institutes in universities, colleges and research centres which provided some 1,300 teachers with opportunities to attend specially designed courses in science. In 1957 some ninety-five such institutes, serving about 4,750 teachers, will be held under Foundation auspices. Grants were also made to the University of Wisconsin and to Oklahoma A. and M. College for a new type of institute for high-school teachers of science and mathematics, while, as a joint project with the American Association for the Advancement of Science, an experimental travelling science library was circulated among schools in outlying communities ill-served with libraries. Reassuring evidence was forthcoming during the year that the downward trend in enrolment for courses in science and mathematics had ceased.

Forty senior post-doctoral fellowships were granted during the year under a new scheme to meet the needs of more advanced and mature scientists. Besides these, 80 post-doctoral fellowships for advanced study in the natural sciences and 775 pre-doctoral graduate fellowships were awarded for the academic year 1956–57. With support from the Foundation, professional organizations of scientists and engineers co-operated in the establishment and maintenance of the National Register of Scientific and Technical Personnel, which now includes about 140,000 scientists and engineers, and utilizing these data the Clearinghouse of Scientific Personnel Information has established itself as an authoritative centre for such information.

The Foundation is also concerned to improve scientific communication and information services, and in May 1956 supported a meeting to discuss the need for fundamental research on the organization of information. Meanwhile, its programme in aid of scientific publications is designed to carry scientific periodicals and reference tools through genuine emergency periods and assist publication of scientific monographs or reference volumes which could not be printed without help. Besides emergency support for the *Transactions of the American Metallurgical Society*, the Foundation has given assistance during the year to *Biological Abstracts*, to a critical compilation of crystal data by the American Crystallographic Association, to the analysis and correlation of visual observations of variable stars by the American Association of Variable Star Observers, to a punched card catalogue of double-star measures at the Lick Observatory and to the Chemical–Biological Co-ordination Center of the National Research Council. During the year the Foundation's Office of Scientific Information began to assist in making the 20,000 odd unclassified scientific reports, issued yearly by organizations engaged in Government-sponsored research, available to scientists everywhere. In view of the success of the project for the translation of the *Journal of Experimental and Theoretical Physics of the U.S.S.R.*, the Foundation made a further grant to enable the American Institute of Physics to begin publication of translations of three additional Russian periodicals, the *Journal of Technical Physics*, the physics section of the *Proceedings of the Academy of Sciences of the U.S.S.R.* and the *Journal of Acoustics*, while it continued to support the work of the Russian Scientific Translation Centre of the Library of Congress.

Alone, or jointly with other bodies, the National Science Foundation sponsored during the year twenty-nine conferences to examine special areas of science, chiefly where adequate support was not otherwise available. The subjects included: metabolic aspects of transport across cell membranes; tissue elasticity; nuclear geophysics; recent advances in invertebrate physiology; microneurophysiology of the synapse; systematics; application of mathematics to engineering; molecular quantum mechanics; low-temperature research; geophysics; chemical reactions in urban atmospheres; high-energy nuclear physics; cosmic distance scale; quantum interaction of the free electron; metabolism of mucopolysaccharides; spectroscopy; quantitative biology; and earthquake engineering; as well as the world symposium on applied solar

energy, the fourth international congress on physical optics, and the second international congress on acoustics.

Recent developments affecting the scientific community discussed in the first part of the director's report include the surveys of the scientific potential of the United States, in which the Foundation's Office of Special Studies has participated; science and scientific man-power in the U.S.S.R.; and the work of the National Committee for the Development of Scientists and Engineers formed by the President on April 3, 1956, which has already formed two working groups, one to expand the supply of qualified technicians and the other to promote long-term improvements in the teaching of science and mathematics in elementary and secondary schools. Besides a note on activities in the International Geophysical Year, reference is made to attempts to overcome difficulties in recruiting and retaining scientific personnel in Government service, and to the action taken to implement the recommendations of the Foundation's Special Commission for Rubber Research, appointed to recommend what future Federal support, if any, should be given to research on synthetic rubber and the course to be followed with regard to the Government laboratories at Akra. An Advisory Panel for High Polymer Research was appointed in February 1956.

THE OBSERVATORY OF HAUTE-PROVENCE

THE Observatoire de Haute-Provence, which is 2½ kilometres from the village of Saint-Michel, stands in grounds about 100 hectares in area which were acquired at the end of 1937. Building commenced in 1938 and was well advanced when the Second World War broke out; although this and the German occupation of France were responsible for considerable diminution of the work, it was never completely interrupted and since 1947 has been normal. The site was chosen because of its low cloudiness and it was found that the quality of images was practically independent of the height between 600 and 1,100 metres. Previous tests extending over twelve years with an 81-cm. telescope lent by Mme. Dina-Britt, at the Observatory of Paris, and provisionally installed at Forcalquier, close to the selected site, showed that for photographic, photometric and spectroscopic work this district was capable of providing excellent results. An additional advantage was found in the facility for transport from other parts of France to Saint-Michel.

The Observatory is under the control of the Centre National de la Recherche Scientifique, and in principle it is open to all French astronomers (and eventually to other astronomers who are engaged in research in astrophysics). It occupies a plateau covered for the greater part with stunted oaks at an altitude of about 650 metres, and tests showed that this is free from local disturbances. Visiting astronomers, after carrying out research there for a few weeks, are free to study the results at leisure in their own establishments, but all photographs, spectrograms and other records remain the property of the Observatory, to which they must eventually be returned. Thus the Haute-Provence Observatory participates in a most efficient manner in the general progress of astronomy, contributing to the activity of all the French observatories. The history, organization, work and equipment of the Observatory are described in a booklet* recently published by the Centre National de la Recherche Scientifique.

The isolation of the Observatory requires that a large part of its personnel should live near by, and ample arrangements have been made for this as well as for those who come to carry out research. This is fully described under "Habitations et Installations Diverses", and a plan of the grounds with positions of the equipment, workshops, etc., appears on p. 10. There are twenty-one excellent plates showing the 120-cm. telescope, its dome, the dome of the 193-cm. telescope which will be in use this year, the spectrograph in the electronics room, mounted on the 120-cm. telescope, and other equipment, as well as photographs of M 13, the spiral nebula in Coma, the central parts of M 31, the Great Nebula in Orion, M 8 photographed by isolating the red Hα line of hydrogen, the nebulæ NGC 5194 and M 81 and the central region of the Milky Way photographed in blue light and also in infra-red.

The director of the Observatory is Prof. Jean Dufay, director of the Lyons Observatory, and the assistant director is Prof. M. Fehrenbach, director of the Observatory of Marseilles. M. Davidson

* Observatoire de Haute-Provence. Pp. 23+21 figures. (Paris: Centre National de la Recherche Scientifique, 1956.) 600 francs.

VEGETATION AFTER FIRE

THE responses of herbaceous vegetation to fire have been the subject of observations by J. R. Sweeney (*Univ. Calif. Publ. Bot.*, **28**, No. 4, 143; 1956). The author points out that, in the chaparral regions of California, fires are frequent, the same areas being liable to periodic reburning. A conspicuous result is the seemingly sudden abundant appearance of plants not previously evident—sometimes described as 'burn' species. The floristic changes in these areas present many problems of interest to the botanist. As a result of detailed study of some ten burnt areas, which are described and illustrated in this memoir, the author has reached the following conclusions.

The vast majority of plant seedlings occurring on burns are from viable seeds present in the soil before the occurrence of fire. The dispersal of seeds on to burnt areas from plants present on adjacent sites does not contribute materially to the herbaceous cover. An important factor in the situation is that soil acts as an effective insulator against heat penetration. Thus the temperatures produced during fires at ¼ in. and 1 in. levels below the soil surface are generally lower than the upper limits of heat tolerance of air-dry seeds. The moisture content of seeds is correlated with heat tolerance. The marked population-changes during the first, second and third years on burns are attributable to differences in germination behaviour of seeds of different species and to the action of fire in stimulating germination and providing suitable habitat conditions for growth. The striking fluctuations exhibited by species with refractory seeds are apparently not due to the effects of ash on germination behaviour, inhibiting sub-

stances exuded by the plants, or to 'competition'. Plants which characteristically occur on burnt land possess genetically predetermined physiological tolerances which pre-adapt them to the fluctuating environmental conditions present in chaparral regions subject to fire. Indeed, the frequent occurrence of fires is essential to the persistence of certain herbaceous species in the flora of the chaparral regions. The failure of fires to occur within the viability periods of the seeds of the component species would result in their becoming rare or disappearing completely.

X-RAY STUDIES OF THE WHEAT PROTEIN COMPLEX

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AND

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WHEAT flour owes its pre-eminence for bread-making to its ability to form a dough with a degree of elastic extensibility not found in the doughs of other cereals. This behaviour is primarily associated with the protein, normally isolated from dough as gluten, a complex mixture of hydrated proteins containing small amounts of lipids and starch. Though gluten has been separated into various crude fractions —notably gliadin and glutenin, respectively soluble and insoluble in 70 per cent aqueous ethanol—none of its protein components has yet been crystallized. X-ray studies of wheat protein[1,2] have therefore been confined to amorphous, or mechanically oriented, heterogeneous specimens. In the present investigation we have re-examined several materials first studied by Hess and his collaborators[1] and, with one noteworthy exception, we have obtained similar results. We have, however, considerably extended these earlier X-ray studies, with particular reference to the bound lipids of flour.

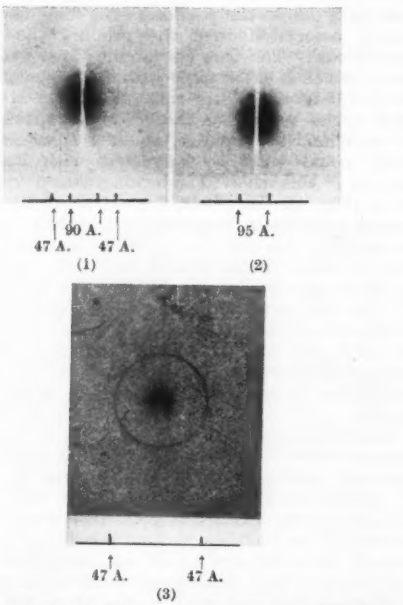
Intact Grains and Flour

Sections of the endosperm of wheat, rye, maize, groats, rice and barley were photographed on a low-angle focusing camera[3]. All showed a spacing at about 90–100 A., which was replaced by a far more intense and diffuse region of scattering at 95–115 A., when the specimens were wetted. These spacings were also observed in dry and wet specimens of wheat starch, flour and dough, but not in gluten, which indicates that they are associated with the starch fraction, and not, as suggested by Hess[1], primarily with the protein. High-angle photographs of starch and the endosperm sections also showed identical powder patterns at shorter spacings, providing a further indication that the starches of these cereals have common components. However, we have observed a 90–100-A. spacing in the lipids extracted from flour with petroleum ether, but not in dry starch from the extracted flour, suggesting that this spacing is largely due to a lipid component of the starch fraction.

Wheat grain also showed a spacing at 47 A., not observed in any of the other cereals, but common to all the varieties of wheat examined (Fig. 1). This line appeared very early in the development of the immature wheat grain. Its intensity diminished when the grain was milled to flour, disappeared when the flour or grain was wetted (Fig. 2), and reappeared weakly in dry bread.

Protein Fractions

High-angle photographs of wet and dry gluten, gliadin and glutenin fractions from several wheat



Low-angle X-ray photographs of: (1) Dry wheat grain; (2) Wet wheat grain; (3) Gliadin films (photograph by Dr. A. Franks, cf. ref. 3); (4) Lipoid extracted from flour with acetone; (5) Degraded gluten residue

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varieties showed only the two strong diffuse rings in the 5-A. and 10-A. regions, commonly observed in proteins in a disorganized state. However, denatured gluten showed a weakening of the 5-A. ring and the appearance of a fairly sharp spacing at 4·65 A., as in disoriented β-keratin[4]. A relationship with the keratin–myosin group of fibrous proteins is also suggested by the approximately 2 to 1 reversible elasticity of moist glutenin[2]. Moist gliadin, however, was inelastic, though very extensible.

The 47-A. spacing characteristic of wheat grains was observed in dry gluten but not in starch, and wet gluten showed only a weak spacing at 51 A. Oriented specimens of gliadin were prepared by evaporating an aqueous ethanol solution on waterproofed glass slides, to give thin films (about 30μ)[5]. Strips of these films were packed together and photographed with the X-ray beam parallel to their surface. The photographs showed sharp orientation of the plane of the 47-A. spacing parallel to the surface of the gliadin films (Fig. 3), but no orientation of the diffuse rings at 5 A. and 10 A. was observed.

Lipid Fractions

We have obtained strong indications that the 47-A. spacing is due to the portion of the flour fat which is closely associated with the protein, the so-called 'bound fat'. The free fat (about 1 per cent of the flour), which is extractable with cold petroleum ether, showed a broad diffuse ring (40–80 A.) in the low-angle region as well as the 90–100-A. spacing. Part of the bound fat (lipid *A*, about 0·3 per cent of the flour) could then be extracted with cold moist acetone; this showed a strong sharp spacing at 47 A. (Fig. 4). However, the extracted flour, which gave a good bread, somewhat reduced in volume but of excellent texture, still contained about 0·6 per cent of more firmly bound fat, and the degraded gluten from it (see below) still showed a 47-A. spacing. The lipoidal materials extracted by acetone from the wholemeals of maize, barley and groats did not show the 47-A. spacing, whereas it was observed in the acetone extract from rye, a cereal with limited baking properties though much inferior to wheat in this respect.

After drying, lipid *A* (found: P, 0·5 per cent) became readily soluble in non-polar solvents and sparingly soluble in dry acetone. It was fractionated by precipitation from ether solution with acetone, followed by chromatography on silicic acid[6]. Though several of the fractions showed the 47-A. spacing, in two of them (*B* and *C*) it was particularly strong and sharp; they were about 4 per cent and 2 per cent respectively of lipid *A* (found in *B*: P, 2·9; N, 2·1; in *C*: P, 4·9 per cent). Further investigation of these phospholipid fractions and of the more firmly bound lipid is continuing.

Oriented specimens of the two phospholipid fractions were prepared by pressing and stroking the materials between sheets of thin 'Cellophane'. These, together with the fat, were then cut into strips, packed together and photographed with the X-ray beam parallel to the surface of the fat layers. In both fractions the plane of the 47-A. spacing was sharply oriented parallel to the fat layers, and in fraction *B* several similarly oriented higher orders of the 47-A. spacing were also observed.

Degradation of gluten by *Clostridium aerofoetidum* (an organism found therein[7]) left an extremely insoluble residue (yield, about 5 per cent w/w; found: P, 0·8; N, 2·3; fat by acid hydrolysis, about 50 per cent). X-ray photographs of this residue showed an extremely strong, sharp 47-A. spacing (Fig. 5), together with several higher orders, and a complete replacement of the diffuse 5 A. and 10 A. rings by several sharp powder lines. Specimens obtained from different wheat varieties showed very similar X-ray patterns, though small differences in the high-angle region were observed. The X-ray patterns of the hydrolysed lipids from this residue, from flour (previously defatted with petroleum ether), and from the acetone extract *A*, had several identical features.

Conclusions

Because of the chemical and structural complexity of cereals, our investigation has been largely exploratory and limited to general features rather than precise details of structure. The relationship with the keratin–myosin group of proteins suggests that protein fibres of this type are mainly responsible for the elasticity of the wheat gluten complex. The low-angle X-ray pattern, which distinguishes wheat from other cereals and varies greatly with the physical condition of the protein complex, is associated with the bound fat, and in particular with the phospholipids. The orientation of the 47-A. spacing in gliadin and in the phospholipid fractions suggests that the protein fibres are held together by layers of the phospholipid, with the fat molecules roughly perpendicular to the protein fibres. In the light of recent X-ray studies of other phospholipids[8], and the preponderance among flour lipids of C_{18} fatty acids, these phospholipid layers are probably in the form of bimolecular leaflets.

Though the bound fat constitutes less than 5 per cent of gluten, it has been found in far higher concentrations in some glutenin fractions[9], and in the type of structure postulated might be expected to have a considerable influence on the cohesive and water-absorbing properties of the whole gluten complex. These suggestions concerning the structure of wheat protein, with close association between the protein and phospholipid components, find support in observations elsewhere, among which are the effects on baking quality of removing the flour lipids[10,11], of adding more fat[10], and of modifying the lipids by the action of gaseous flour improvers[12].

This work is being supported by a grant from the Research Association of British Flour-Millers and represents a co-operative X-ray chemical investigation by workers at Birkbeck College (University of London) and the Cereals Research Station, respectively. We are particularly grateful to Prof. J. D. Bernal and Dr. T. Moran for their interest and encouragement and for many helpful suggestions.

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HISTOCHEMICAL DEMONSTRATION OF CHOLINESTERASE AND 5-NUCLEOTIDASE IN NORMAL AND DISEASED HUMAN MUSCLE

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AND

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VERY little histochemistry has been carried out on skeletal muscle and even less on either normal or diseased human muscle. It is of interest, therefore, to summarize some of the results which we have obtained with two histochemical techniques on normal and diseased human muscle.

Cholinesterase was demonstrated by Gomori's modification[1] of the method of Koelle and Friedenwald[2] and specificity was confirmed by the use of eserine. Fresh frozen sections were incubated in the substrate mixtures for periods of up to ½ hr.

5-Nucleotidase was demonstrated by the method described by Gomori[3], in acetone-fixed material, using incubation periods of 16, 20 and 24 hr. Control sections were incubated in a medium containing glycerophosphate instead of adenylic acid.

Material was obtained post-mortem within one hour of death, at operation or by biopsy. The last method was used for obtaining specimens from patients suffering from periodic paralysis, carcinomatous neuropathy or myopathy, facio-scapulo-humeral dystrophy, pseudo-hypertrophic muscular dystrophy, familial dystrophy, myopathies or neuropathies of unknown origin, motor neurone disease and polyneuritis or polymyositis.

Cholinesterase : normal muscle. There have been a number of papers describing the localization of cholinesterase in motor end-plates in both animal and human skeletal muscle[2,4–9].

We have noted the presence of several types of cholinesterase-positive structures in normal human muscle.

(1) Small 'classical' end-plates (that is, end-plates like those described by Koelle) arranged in straight rows across muscle fibres or in groups (Fig. 3).

(2) 'Plates' composed of parallel gutters arranged as a cake frill or palisade, the gutters being oriented in the same direction as the long axis of the muscle fibre (Fig. 4).

(3) Large cap-shaped areas situated over the ends of muscle fibres, with gutters arranged in parallel or in somewhat reticular pattern. These endings are, in fact, situated at the musculo–tendinous junctions. They are also found when muscle fibres end in the middle of a bundle. The possibility exists that these may not be motor end-plates but stretch receptors—if this is so, then the presence in them of specific cholinesterase becomes of some interest (Fig. 1). Similar structures have been observed in skeletal muscle of various animals by Couteaux[10] and Gerebtzoff[11].

In addition, there are a number of less well-defined structures, for example, spirally arranged gutter-like structures or areas consisting of small islets of gutters extending over considerable lengths of muscle fibre (Fig. 5). Variations on the latter theme could be seen in some cases, and in others parallel gutters could be seen arranged transversely across the muscle fibre. Note also in Fig. 5 granules of positive material along the edges of the muscle fibres.

It is of interest that a positive reaction was found only in 'classical' end-plates when butyryl thiocholine was used.

We have on several occasions seen more than one motor end-plate to a muscle fibre.

In addition to these cholinesterase-definitive structures, we obtained a moderate diffuse positive reaction for the enzyme in the substance of the muscle fibre with, in some cases, a deeper reaction along the sarcolemma. Our belief that this is due to cholinesterase is based upon a number of reasons, of which we quote the following.

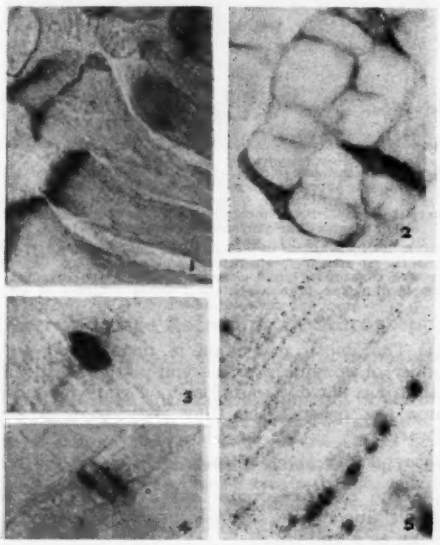

Fig. 1. Acetyl cholinesterase in musculo-tendinous junctions of normal muscle. It is suggested that the positive structures may be stretch receptors

Fig. 2. Acetyl cholinesterase in muscle fibres, showing a more intense reaction in the more atrophied fibres. This muscle was taken from a case of polymyositis

Fig. 3. Acetyl cholinesterase in a 'classical' end-plate situated in muscle taken from a case of motor neurone disease

Fig. 4. Acetyl cholinesterase in a 'cake-frill' or palisade type of structure in normal muscle. It is suggested that this type of structure may be a form of stretch receptor

Fig. 5. Acetyl cholinesterase distributed in various structures in a piece of iliacus taken during cup arthroplasty of hip

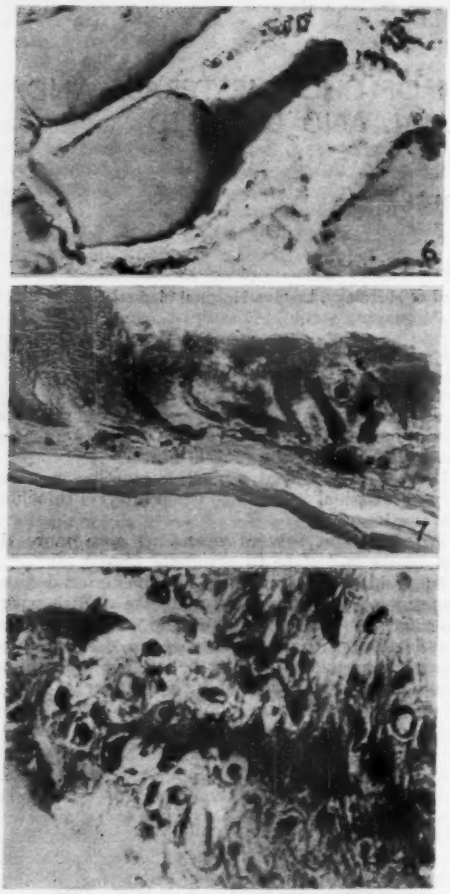

Fig. 6. 5-Nucleotidase in muscle from a case of familial dystrophy. The enzyme appears to increase as the muscle fibre atrophies
Fig. 7. 5-Nucleotidase in a muscle fibre from a case of motor neurone disease. Positive capillaries appear to be embedded in and destroying the muscle substance

Fig. 8. 5-Nucleotidase in muscle taken from a case of (?) polymyositis (?) pseudohypertrophic muscular dystrophy. Enzyme-positive connective tissue elements appear to be invading an atrophied muscle fibre which itself shows evidence of strong 5-nucleotidase activity

(1) The depth of colour is not related to the number of enzyme positive end-plates on the fibre, so that it is not due to diffusion. Even when no end-plates are present the fibre may show a strong coloration.

(2) The reaction is inhibited by eserine.

(3) The reaction occurs only very slightly when butyryl thiocholine is used instead of acetyl thiocholine as a substrate.

Cholinesterase in pathological muscle. There appears to be no decrease of cholinesterase in any of the myopathies or neuropathies examined—if there is any change at all, it is in the direction of increased activity. Atrophying muscle fibres, in fact, show a more intense diffuse reaction for the enzyme in the substance of the fibre (Fig. 2).

Even in muscle undergoing severe degeneration, the structure (except in a few cases) and the cholinesterase activity of motor end-plates persist, the motor end-plate being sometimes virtually the only structure left. Since parts of muscle which have motor end-plates seem to survive longer than other parts of the fibre, it is possible that end-plates and/or the enzyme present in them exert some protective influence.

5-Nucleotidase. The reaction for this enzyme in normal human muscle tissue is slight or absent. Where it occurs it seems to be restricted mainly to the walls of larger blood vessels and to nerve fibres, but is occasionally seen in other connective tissue elements, for example, fibroblasts in tendon, and cells and fibres of loose connective tissue. It is of interest that the enzyme is not found in all of the larger blood vessels, but appears to be associated only with certain of them. It is not at all clear what determines whether or not the enzyme shall be present in a particular blood vessel.

In only one specimen of normal muscle did we observe a strong reaction for 5-nucleotidase in connective tissue, and in this instance there was evidence of an inflammatory lymphocytic reaction in this region. In about a quarter of our specimens of pathological muscle we observed a large increase in the amount of 5-nucleotidase present. This was seen in six cases of muscular dystrophy of various types, where there had been a considerable degree of muscle fibre atrophy and a corresponding increase in interstitial connective tissue, but it was also seen in one case of myopathy and one of motor neurone disease where there had been no increase in the amount of connective tissue present. In other specimens we observed a smaller increase in enzyme activity. But these changes in enzyme concentration were never in any way correlated with clinical diagnosis and a large proportion of our muscle samples gave little or no reaction, like normal specimens.

We noticed that atrophied degenerating muscle fibres (but not, as a general rule, fibres undergoing simple atrophy) gave a strong positive reaction in the muscle substance itself (Fig. 6). In addition, we frequently observed that capillaries (Fig. 7), cells (Fig. 8) and connective tissue fibres which were invading and destroying muscle fibres also possessed a high concentration of 5-nucleotidase. Where connective tissue was present in great amounts, all the elements in it gave strong enzymic reaction.

The glycerophosphate control sections were always negative, which suggests that in the connective tissue of human muscle there is a specific 5-nucleotidase.

5-Nucleotidase dephosphorylates muscle adenylic acid and it may well be that increased activity of this enzyme together with the apparent invasion and destruction of the muscle fibres by the connective tissue elements may be a significant factor in the wide range of muscular diseases examined by us.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Generation of Polarized Light in the Crab Nebula

It does not appear to have been noted previously that the polarized light emitted by the Crab Nebula could be generated in an elementary manner. In the collisions between high-velocity clouds of presumably ionized matter, polarized light could be generated due to bremsstrahlung. This radiation would be generated primarily in the collisions between the electrons of one cloud and the nuclei of a colliding cloud.

Depending upon the velocity with which such a collision takes place, the light emitted is either polarized primarily parallel or perpendicular to the relative velocity of the two clouds.

Consider the collision of an electron of velocity v_0 and a nucleus of charge Z. Classically, if the impact parameter is small, the acceleration of the electron is primarily parallel to v_0 and high-frequency radiation is emitted. Thus, near the high-frequency limit of the bremsstrahlung spectrum, the radiation is linearly polarized with its electric vector parallel to v_0. If the impact parameter is large, the electron is deviated only slightly, the frequency of the emitted radiation is low and the acceleration and polarization of the emitted radiation is perpendicular to v_0. Sommerfeld[1] has calculated the degree of polarization quantum mechanically, implicitly averaging over impact parameters. His results are illustrated in Fig. 1. The observation direction is perpendicular to v_0. The limiting frequency ν_g is given by $h\nu_g = \frac{1}{2} m v_0^2$.

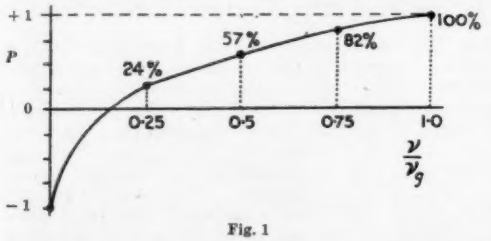

Fig. 1

Minkowski[2] has estimated the optical radiation of the Crab Nebula to be $3{\cdot}4 \times 10^{21}$ ergs/sec.-cycles/sec. at $\lambda = 4250$ A. or $\nu = 7{\cdot}06 \times 10^{14}$ cycles/sec. The volume of the amorphous part of the nebula is[3] $V \sim 10^{65}$ cm.^{3} and its distance is assumed to be 1,100 parsecs. Therefore, the power radiated per cycle/sec. per unit volume is, roughly,

$$P_{\nu\text{obs.}} = 3{\cdot}4 \times 10^{-34} \text{ erg/sec.cm.}^3\text{-cycles/sec.}$$

In the collision between a stream of electrons of density n with n' nuclei per unit volume, the power radiated has been calculated by Kramers[4]:

$$P_\nu = \left(\frac{32\pi^2 Z^2 e^6}{3\sqrt{3}.\, m^2 v_0^2 c^3}\right)(n' v_0)(n)$$

Let $n = n'$ and $Z = 1$. A reasonable value for v_0 might be the observed[5] velocity of expansion of the Crab Nebula. This is $v_0 \cong 10^8$ cm./sec. and corresponds to $\nu_g \cong 7 \times 10^{14}$ or $\lambda_g \cong 4300$ A. For 7000 A. $> \lambda >$ 4300 A. the polarization would be parallel to v_0 and greater than 75 per cent. With these assumptions,

$$P_\nu = 3{\cdot}3 \times 10^{-40} n^2$$

Since each cloud presumably contains n protons and n electrons per unit volume, this result should be multiplied by 2 and compared with $P_{\nu\text{obs.}}$. We then find that $n_{\text{av.}} \cong 700$ cm.$^{-3}$ and that the mass of the nebula is about six solar masses. Since only a fraction of the clouds in the nebula would be in collision at a given time, this result should be multiplied by some unknown factor. This estimate of the mass is rather high; the Crab Nebula is generally believed to possess 1·5–2 solar masses. However, considering the roughness of the estimate, the agreement must be considered reasonable.

Instead of visualizing the nebula as consisting of high-velocity streams of electrically neutral ionized matter, it might be considered to possess high-velocity streams of electrons which interact with essentially stationary nuclei. In this connexion, observations[6] of high-velocity ($\sim 3 \times 10^9$ cm./sec.) disturbances in the nebula may be particularly significant.

It should be emphasized that this mechanism requires a flux of electrons with a few electron volts of energy rather than the flux of $\sim 10^{11}$ eV. energy electrons and the rather strong magnetic fields required by the synchrotron mechanism[7]. Observationally, it should be possible to distinguish between the mechanisms, since the polarization of synchrotron radiation should be independent of frequency, whereas the polarization of bremsstrahlung is rather sensitive to frequency.

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Electron-Image Recording by Xerography

The electrophotographic process of xerography[1], initially described for the recording of optical images, has since received a considerable amount of attention with regard to its application in medical and industrial radiography[2,3]. The mechanism of image formation depends, primarily, on photoconductivity produced in a film of a black vitreous form of selenium by the incident radiation. To date, xerography has been used satisfactorily for recording images formed by visible light, ultra-violet radiation and X-rays. The observation, by Pensak, of induced conductivity in a thin film of amorphous selenium during electron bombardment[4] suggested the possible application of xerography to the recording of electron images of the type produced in electron microscopes and electron diffraction cameras. During the course of an electron diffraction investigation of the structure of evaporated selenium films, some preliminary experiments of this kind have been carried out.

Fig. 1. Photo-copy of a transmission-type electron diffraction pattern from a gold foil; recording by xerography. Spurious background markings are electrical artefacts resulting from the use of a poor quality plate. (× 1)

Using an accelerating voltage of 50 kV., electron diffraction patterns have been recorded on vitreous selenium films about 60 microns thick, developed for use with X-radiation. With the present experimental arrangement, the plate is charged before loading into the apparatus and is required to retain the charge for a period of about ten minutes while evacuation is taking place. The plate is then exposed to the pattern in the normal manner, and after removal from the camera, developed with a powder cloud[5]. When examined using illumination at oblique incidence, the resulting image has a general appearance illustrated by Fig. 1. In this particular case the plate was initially charged negatively. Electrons contributing to the diffraction maxima have discharged the plate and the background has been developed afterwards with a positively charged powder cloud. The diffraction maxima are thus characterized by the absence of powder in the resulting image.

A limited number of experiments has shown that, using 50 kV. electrons, the particular selenium plates employed require an exposure similar to that used with Ilford *N*.50 photographic emulsions. A diffraction pattern just visible on the fluorescent screen requires an exposure time of about five seconds. From the measurement of the ring diameters of a gold transmission pattern (Fig. 1), there is no evidence of electron refraction in the electric field associated with the initial charge on the surface of the plate. The d_{hkl} values calculated from the measured ring diameters on a xerograph are in agreement with values calculated from a conventional photograph to better than $\pm$ 0·05 per cent, the limit of the experimental observations.

The advantages offered by xerography for various types of image recording have been discussed in the literature[3]. The following points are of particular interest with regard to the possibility of using the technique to record electron images: (1) The vitreous selenium plates are free from out-gassing effects at room temperature. (2) Xerographic plates of the type developed for radiography can be used for recording electron images produced in electron optical instruments using beam accelerating voltages between 45 and 55 kV. (the only range so far investigated). (3) Such plates require an exposure similar to that used with the high-contrast photographic emulsions commonly employed in electron microscopy and electron diffraction. (4) The use of suitable liquid developing techniques makes possible image resolution beyond the limits attainable with conventional photographic materials[6], without sacrificing the plate sensitivity. (5) The high image-contrast and wide latitude of exposure that have been demonstrated with xero-radiography could be advantageous in the recording of electron microscope images, which frequently exhibit low relative contrast.

Thanks are due to Prof. C. J. B. Clews for providing the facilities for carrying out this preliminary investigation and to Dr. L. N. D. Lucas for his helpful supervision. I am much indebted to Mr. K. A. Metcalfe and Mr. W. G. Norgard for their assistance and interest. The work has been supported by a Commonwealth Scientific and Industrial Research Organization Australian Postgraduate Studentship.

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Calculation of Particle-size Distribution from Sedimentation Observations

The calculation of the size distribution of the particles of a powder in a suspension, from a knowledge of the mass of the material which has crossed some horizontal plane at a known distance, h, below the surface of the suspension, is of considerable importance, since it is the basis of the evaluation of test data obtained on a number of types of instrument used in powder technology. So far as is known, however, none of the previous derivations of the required relationship is completely satisfactory; the following proof, however, appears to be rigorous and general.

At the commencement of the test the powder is evenly dispersed in the column of fluid above the reference plane. As the test progresses, the mass of material which has crossed the reference plane is determined, at times t measured from the commencement of the trial, in some way.

Consider first a suspension of exactly similar particles, evenly dispersed initially. Since the particles all fall at the same speed, the total mass, m, crossing the reference plane increases at a uniform rate until a time such that a particle starting at the surface will have reached this plane; thereafter this mass is, as shown in Fig. 1, constant.

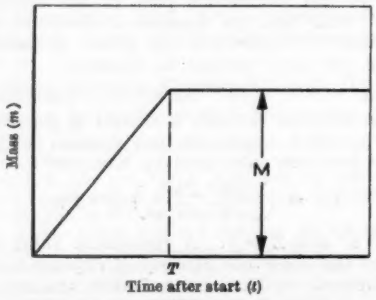

Fig. 1

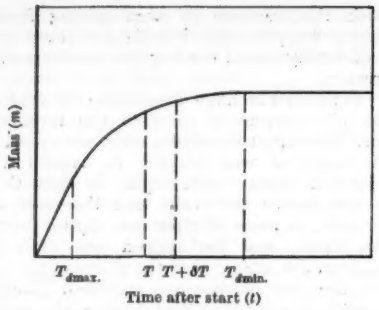

Fig. 2

From this figure it follows that the total mass, M, of the material in the whole of the column above the reference plane is given by the value of m for the horizontal portion of the curve and also by the expression :

$$M = -\text{(change of gradient at } t = T) \times T \quad (1)$$

where T is the time for a particle to fall the distance h. It should be emphasized that T is distinct from t.

Now equation 1 may be written :

$$M = -\text{(change of gradient at } t = T) \times (t \text{ at } t = T) \quad (2)$$

For a group of particles of uniform density, in which a range of sizes is present, the curve of m against t will have the form shown in Fig. 2. This curve has an initially straight portion arising from the steady fall of all sizes present through the reference plane ; this linear relationship holding until $t = T_{d\,max.}$ (the time for the largest particle present to fall the distance h). Thereafter the gradient diminishes as the particles of progressively smaller size cease falling through the reference plane.

After $t = T_{d\,min.}$ (the time for the smallest particle to fall the distance h), all the particles will have crossed the reference plane and the curve is horizontal ; the value of the ordinate then representing the total mass of material, above the reference plane, in the original suspension.

Consider now a part of the curved portion of this graph between $t = T$ and $t = T + \delta T$.

From equation 2 above, and from the additive property of gradients, it follows that, as a first approximation, the mass of particles requiring times lying between T and $T + \delta T$ to fall the distance h is :

$$-\text{(total change of gradient from } t = T \text{ to } t = T + \delta T) \times (t \text{ at } t = T) \quad (3)$$

but an error due to the finite value of δT is involved. This error vanishes as δT tends to zero.

The change in gradient can be expressed as :

$$\frac{d^2m}{dt^2} \cdot \delta T \text{ (for } t = T)$$

where again the error vanishes in the limit.

Thus, from equation 3, the mass of particles which require times between T and $T + \delta T$ to fall the distance h is given by :

$$-\frac{d^2m}{dt^2} \cdot t \cdot \delta T \text{ (for } t = T)$$

If M_T is the mass of particles which fall the distance h in times less than T it follows that :

$$\delta M_T \text{ (for } T \text{ to } T + \delta T) = -\frac{d^2m}{dt^2} \cdot t \cdot \delta T \text{ (for } t = T)$$

or

$$\left(\frac{\delta M_T}{\delta T}\right)_T = -\frac{d^2m}{dt^2} \cdot t \text{ (for } t = T)$$

Thus, in the limit,

$$\left(\frac{dM_T}{dT}\right)_T = -\frac{d^2m}{dt^2} \cdot t \text{ (for } t = T) \quad (4)$$

or

$$M_T = -\int_0^T \frac{d^2m}{dt^2} \cdot t \cdot dt$$

Integration by parts gives :

$$M_T = -{}_0^T\left[\frac{dm}{dt} \cdot t\right] + \int_0^T \frac{dm}{dt}\, dt$$

$$M_T = m - \frac{dm}{dt} \cdot t \text{ (for } t = T) \quad (5)$$

or

$$M_T = m - \frac{dm}{d(\ln t)} \text{ (for } t = T) \quad (6)$$

So far, the particles have, in effect, been graded with respect to time. In order to grade with respect to diameter, a relationship between T, the time required for a particle to fall distance h, and the diameter must be introduced.

If Stokes's law is used for this purpose, then

$$D = k\sqrt{1/T} \quad (7)$$

where

$$k = \sqrt{\frac{18\mu h}{g(\rho - \sigma)}}$$

When the scale of time T, for the curves of M_T against T, obtained from equations 5 or 6, is transformed to one of particle diameter by the use of equation 7, a curve of M_D against D is obtained ; M_D being the mass of particles with diameters greater than D.

If this process is applied to the graph of $\frac{dM_T}{dT}$ against T obtained by the use of equation 4 it is also necessary to multiply the ordinates by $\frac{dT}{dD}$ to give values of $\frac{dM_D}{dD}$.

From equation 7,

$$\frac{dT}{dD} = -\frac{2}{k} T^{3/2} \quad (8)$$

Thus, from equation 4,

$$\left(\frac{dM_D}{dD}\right)_D = -\frac{2}{k} t^{5/2} \frac{d^2m}{dt^2} \text{ (for } t = T) \quad (9)$$

Thus equations 4, 5, 6 and 9 may be used in practice. Equation 4, which gives a size distribution on a time basis, requires a double differentiation, but is suitable for numerical computation. Equations 5 and 6 give oversize curves on a basis of time and require a single differentiation.

When a knowledge of the actual particle-size is required, the use of equation 9 in conjunction with equation 7 leads to a size-frequency curve in terms of the Stokes's diameter.

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Shape of a Liquid Interface

In problems involving the determination of molecular areas of adsorbed or spread films at an interface, it is frequently necessary to know the liquid–liquid or liquid–vapour interfacial area precisely. Unless large containing vessels are used, the curvature of the interface near their walls may produce appreciable uncertainty in estimates of the true area, and under these conditions it is important to know the extra interfacial area resulting from this curvature.

If we consider the interfacial curvature at a long plane vertical boundary in an infinite liquid, one of the principal radii of curvature is infinite and the problem is essentially two-dimensional. Thus, for equilibrium at the interface we have:

$$\frac{T}{R} = g(\rho_2 - \rho_1)y \qquad (1)$$

where T is the interfacial tension, R the principal radius of curvature, ρ_1 and ρ_2 the densities of the two phases and y the height above the free surface. The derivation of the equation of the surface is straightforward and the result, given by Rayleigh[1], is

$$\left.\begin{aligned} x &= -2a\cos\frac{\theta}{2} + a\ln\cot\frac{\theta}{4} + K \\ y &= 2a\sin\frac{\theta}{2} \\ a^2 &= T/(\rho_2 - \rho_1)g \end{aligned}\right\} \qquad (2)$$

where θ is the inclination to the horizontal at the point (x,y). At a vertical boundary with zero contact angle $\theta = \pi/2$, and, putting $x = 0$, this determines K. Inclination of the wall and a non-zero contact angle alter this constant but not the form of the curve.

The increase in length of the meniscus due to its curvature is

$$l = \int_{x=0}^{x=\infty} (ds - dx)$$

where ds is the elementary length of arc. From (2), this is found to be:

$$l = a(2 - \sqrt{2}) \simeq 0{\cdot}586a$$

The calculation should be also nearly exact for a curved boundary provided its radius of curvature is much greater than a. Thus, for a boundary of length p, this gives an increase in area of pl.

The magnitude of the correction can be illustrated by the case of water in a vessel 10 cm. × 10 cm.,

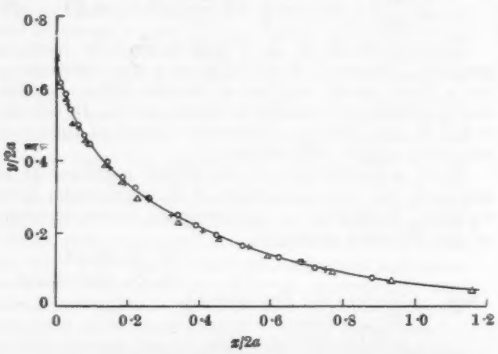

Fig. 1. Shape of interface. Theory: ———. Experiment: ○, water; +, benzene; △, decane

for which the increase in area arising from the curvature is 6·4 per cent. For the interface between liquids of nearly equal density the increase may be even greater.

Some experiments have been done to verify that equation (2) adequately predicts the form of the interface. Air–liquid interfaces only were used. The method employed was slightly to overfill a tank about 10 cm. square with liquid so that the free surface was above the walls and therefore visible from the side. A piece of glass was dipped vertically into the liquid, and the system was then photographed from the side so that the shape of the surface adjoining the piece of glass was recorded. The liquids used were water, benzene and decane, the values of a determined independently being 0·274, 0·184 and 0·180 cm. respectively. Fig. 1 shows the theoretical curve of $x/2a$ against $y/2a$ together with the experimental points, good agreement being obtained.

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X-Ray Measurements on Nettle Fibres

Cellulose is the main constituent of the fibres of the two varieties of nettle, *Boehmeria girardinia heterophylla* and another *Boehmeria frustescens*; their Indian names are 'sishnu' and 'pooah' respectively. Details of X-ray studies of these fibres and the interpretations of the fibre diagrams on the basis of the unit cell given by Meyer and Mark[1] have already been reported[2].

In the present communication, additional work on the dimensions of the intermicellar spaces is described. Silver and gold crystallites were deposited within the intermicellar spaces of the fibre framework. Silver crystallites were dispersed by soaking the fibres in 3 per cent silver nitrate solution and finally drying and treating in 3 per cent hydrazine hydrate solution. The same procedures were repeated for dispersing gold crystallites using 3 per cent gold chloride and hydrazine hydrate solutions. X-ray pictures of these separately treated fibres of each variety were taken in a camera of radius 4·08 cm. in cobalt $K\alpha$ radiation. Since the metal crystallites were embedded within the intermicellar spaces, the silver and gold lines in addition to the fibre diagrams appeared in the X-ray pictures, and these lines were photometered. The breadths at half-maximum of the peaks, obtained from the photometric curves, were measured, and from Scherrer's formula the particle-sizes were calculated. The details of the measurements are given in Table 1.

These results represent an approach to the average values of the dimensions of the intermicellar spaces and the significance of these have been discussed by Frey-Wyssling[2]. The dimensions of the intermicellar spaces of the nettle fibres can be compared with those

Table 1

Fibre of different varieties	Particle-size calculated from gold lines	Particle-size calculated from silver lines
1. Sishnu	91 A.	90 A.
2. Pooah	91 A.	89 A.

of ramie, found to be 84–85 A. by deposition of metals[3], and the greater width of the spaces of these fibres can be accounted for by assuming them to be more loosely built than ramie.

I thank Prof. B. N. Srivastava for his interest in this work.

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Crack Initiation in Hydrogenated Steel

The interaction between hydrogen and steel results in various embrittlement phenomena. For example, it has long been known that flakes, or internal hair-line cracks in alloy steel forgings, are related to the presence of hydrogen retained from the steel-making process. On the other hand, embrittlement of electroplated high-strength steel parts is caused by hydrogen introduced during pickling or electroplating processes. A particularly disturbing form of hydrogen embrittlement is static fatigue, or brittle delayed fracture at relatively low applied stresses[1].

The basic mechanism of these hydrogen-induced phenomena is crack initiation and controlled crack propagation. The time-dependent growth of flakes in heavy steel forgings has been amply demonstrated[2]. Also, static-fatigue failure has been shown to result from the initiation and slow growth of a crack[3].

The crack initiation process is of particular interest, since recent research in this laboratory indicates the existence of a true incubation period for crack initiation. This behaviour is indicated by electric resistance measurements on hydrogen-charged specimens under static load. Notched specimens of 4340 steel (0·40 per cent carbon, 1·7 per cent nickel, 0·85 per cent chromium, 0·25 per cent molybdenum) were charged with hydrogen, plated with cadmium and baked to produce a uniform distribution of hydrogen. Upon loading, an immediate increase in specimen resistance was observed, resulting from a decrease in notch area caused by deformation. The resistance then remained constant for some time, and this is taken as the incubation period. A subsequent increase in resistance resulted from the decrease in notch area caused by crack initiation and propagation.

On this basis, incubation periods varying in length from a few seconds to as long as 18 hr. have been observed. The length of the incubation period depends primarily upon average hydrogen concentration, and is essentially independent of the applied stress.

The existence of the incubation period is compatible with either of the two major theories which purport to explain hydrogen embrittlement. Zappfe[4] suggested that molecular hydrogen might be precipitated in internal 'voids' and build up pressure sufficient to cause premature fracture. On the other hand, Petch and Stables[5] apply the Griffith–Orowan theory of delayed fracture of glass to the case of hydrogen embrittlement. They propose that hydrogen atoms may be adsorbed on the surfaces of internal micro-cracks, thereby lowering the critical stress necessary for extension of the crack.

A critical feature of both theories is that hydrogen does not cause embrittlement unless localized in a small region. The rate of delivery of hydrogen to the potentially embrittled region is controlled by the diffusion-rate of hydrogen in steel. If the average hydrogen concentration is low, then a substantial time interval may be necessary to build up the hydrogen concentration at the point of crack initiation. Thus, the length of the incubation period would be controlled by the average concentration of hydrogen, as was observed.

Consideration of the incubation period is vital to any critical discussion of hydrogen embrittlement. For example, one of the unique characteristics of hydrogen embrittlement is that the fracture ductility decreases with decreasing strain-rate. Of course, this fracture ductility is dependent upon both initiation and propagation of a crack; nevertheless, it is evident that, for a given incubation period, a low strain-rate test will be more likely to detect embrittlement than a high strain-rate test. If the strain-rate is so high that the specimen fractures in less time than the incubation period, then hydrogen embrittlement will not be detected.

This behaviour must be reflected in the design of a suitable test for detection of hydrogen embrittlement. Apparently, a mechanical test will be inadequate if the test duration is less than the incubation period. Since we have observed incubation periods of substantial duration, short time tests such as normal tensile and bend tests may not be discriminating. Thus, under these conditions, the steel may exhibit normal ductility but will still be subject to brittle delayed fracture.

We wish to thank the United States Air Force for permission to publish this communication.

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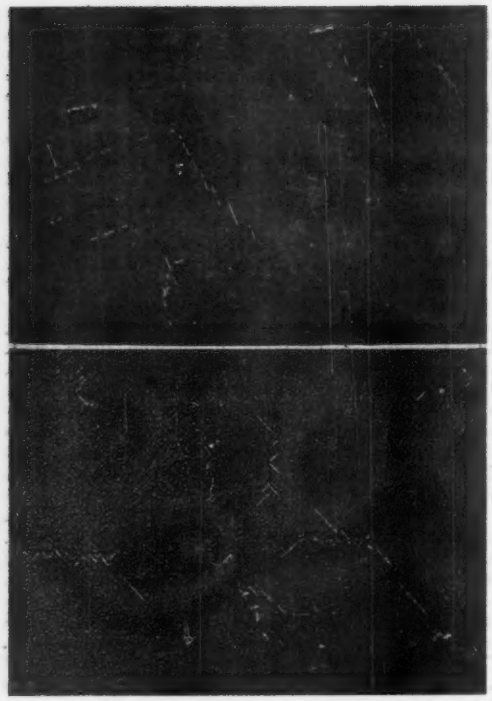
Preferred Precipitation on Dislocation Lines in an Aluminium Alloy

Electron micrographs of aged specimens of aluminium – 4 per cent copper reveal the structures associated with the presence of *GP*1, *GP*2, θ′ and θ, precipitates after various heat treatments[1]. The sequence of formation (with some overlapping) at low temperatures is *GP*1, *GP*2 and θ′, whereas at high temperatures it is θ′ and then θ, the equilibrium phase. At some ageing temperatures precipitation within the lattice is believed to occur preferentially on edge dislocations, and Wilsdorf and Kuhlman-Wilsdorf[2] and Thomas and Nutting[3] have recently demonstrated this in electron micrographs.

We have attempted to trace dislocation lines in an unworked crystal of aluminium – 4 per cent copper by electron microscopical studies of preferred precipitation. High-temperature ageing was used,



the period of heating being chosen so as to produce θ′ precipitates, which form on {100} matrix planes, only at nuclei on the dislocation lines, not elsewhere in the crystal. This is feasible since it is well known that nucleation occurs much earlier at sub-boundaries than in the bulk of the crystal.

A sheet specimen cut from a single crystal of high-purity alloy was used. After being heated at 530° C. for several hours, it was water-quenched and then critically aged for about eight minutes at 250° C. Typical photographs of the traces of two kinds of dislocations observed in the specimen are shown in Figs. 1 and 2. The Burgers vectors of these dislocations were deduced with the aid of the following assumptions: (1) the θ′ phase in general becomes nucleated preferentially only at an edge dislocation (cf. the strain interaction of solute atoms with dislocations[4]); (2) the orientation of the θ′ phase will be such as to relieve the principal stress at the dislocation; thus, knowing this orientation from the photographs, the direction of the Burgers vector can be deduced; (3) the plane of the photographs is practically (001) and the precipitates are formed on {100} matrix planes.

Fig. 1 shows the trace of dislocations similar to those observed by Wilsdorf and Kuhlman-Wilsdorf, emitted into a slip plane from a single dislocation source. The Burgers vector lies along $[10\bar{1}]$ on the (111) plane, and the line of the dislocations is nearly parallel to $[1\bar{2}1]$. Only a section of the entire dislocation line can, of course, be seen in the photograph.

Fig. 2 shows the other type of dislocation. The orientations of the precipitates show that in this case the dislocation lines lie along $[1\bar{1}0]$ and [110] in the (001) matrix plane, and the actual length of the lines, 0·8–1·2 microns, can be measured from the photograph. The Burgers vectors lie along [110] and $[1\bar{1}0]$ respectively. Thus, this dislocation seems to be sessile of the type suggested by Lomer and Cottrell[4], direct evidence for which has previously been lacking. The photograph appears to show a part of the dislocation network, as indicated by the regularly distributed dislocations.

A more detailed account of the work will be published shortly.

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Thermal Conductivity of Soil

Two assertions recently made by J. Webb[1] in commenting on the thermal conductivity of dry soil and in a reply[2] to D. A. de Vries need further clarification.

The first refers to a statement by A. Gemant[3] to the effect that ". . . the resistivity of dry soil would be close to that of air . . ." but omitting the remainder of the statement: ". . . which is contrary to experience". The assumption by Webb that the heat flow through an aggregate of solid spherical particles separated by air may be taken to be uniform and parallel is completely unjustifiable in view of the widely differing thermal conductivities of the two phases involved. Furthermore, no support for any assumption of this nature is to be found in Gemant's work, since he makes no attempt to calculate the effective conductivity of such an aggregate from the conductivities of the constituent solid and air phases. In his first paper[3], Gemant shows that the sphere model for dry soil, if the air phase is excluded, can be reconciled with practical experience by assuming chipping at the points of contact of the spheres to the extent of 10^{-3} of their radius. Since the soils discussed by Gemant contain water, it is clear that the conductivity contributed by chipping of this order of magnitude, and therefore also that of the air phase to which it is equivalent, will be negligible in comparison with the conductivity contributed by the moisture. In his first paper, Gemant therefore justifiably neglects contributions from the air phase, and bases his calculations on the conductivity contributed by the solid and liquid phases only.

Webb seems to be unaware that Gemant's first paper[3] has now been entirely superseded by his later papers[4,5], in which spheres are replaced by a combination of cubes and pyramids with water condensed at the apexes. The air phase in the soil is disregarded and no chipping is assumed. Recognizing that the heat flow in the solid constituent is divergent, Gemant evaluates its thermal resistance by means of an electrical analogue. This model has been found to be satisfactory for soils consisting of a mixture of sand and clay having a wide range of dry density and moisture content, particularly in view of the good agreement with Kersten's experimental results[6]. In a recent paper by K. Mochlinski and myself[7], Gemant's theoretical formula has been combined with

Kersten's empirical formula to produce a nomogram having practical application to a wide range of soils encountered in practice.

The second statement by Webb on which I wish to comment is: "There are almost as many values of soil conductivity as there have been experimenters in the field". This seems to result from Austin's statement in 1939. Since then, however, considerable progress has been made in the calculation and measurement of soil conductivity, with the result that to-day cable engineers and others are able to obtain reliable information from a knowledge of soil constitution and by direct measurement. Apart from work on the subject already carried out, and now being pursued by this Association and others in Great Britain, an extensive programme of research is in existence in the United States, and has been described by Dr. A. W. Burrell[8].

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It is suggested by Mr. M. W. Makowski that I misrepresent Dr. Gemant because I omit part of a statement, with which I find myself in disagreement. The full statement is: "If the spheres were to touch at a geometrical point only, the resistivity of dry soil would be close to that of air, which is contrary to experience". I still believe this statement to be erroneous; and the addition, or the omission, of the final phrase is of no significance. Gemant knows, as do we all, that the actual resistance of a dry soil does not approach to that of air; but in that paper he does not seem to be aware of the important part played by the air phase in a dry soil. He was forced to chip his spheres, not because he wished, thereby, to exclude the necessity of treating the conductance of the air phase, but because he thought that, if spheres touch only at points, then the resistivity of the hypothetical soil would approach to that of air.

I agree with Mr. Makowski when he points out that it is incorrect to assume parallel heat flow in a solid–air composite; the opening paragraphs of my second communication should make this clear.

Dr. de Vries[2] has directed attention to a solution by Lord Rayleigh whereby a value for the resistivity of dry soil, of the order of the observed value, is obtained, without modification of the model particle, by considering the effect of the air phase.

It may, perhaps, be helpful to explain why I adopted what was known to be a non-rigorous approach in my first communication. Gemant adopted[1] a method in which the parallel law is applied to the incremental thermal resistances, and this was followed by integration between known limits. I used a similar method, and was able to show that such a method greatly over-emphasizes the part played by the air. The question which I attempted to pose was this: Is one justified, when using an approximate method of analysis, in neglecting the effect of a phase, simply because the nature of the approximation is to exaggerate the part played by that phase? I suggest that such a method is dangerous, because one is forced to make unlikely modifications to relate calculated to observed data.

Gemant would have been better advised, when modifying his spherical model, to take into greater account the ratio of the porosities of an average soil and the hypothetical soil. He appears to have been misled by a calculation which he made to find the porosity of the hypothetical soil, since he quotes a value of 43 per cent. The correct value is 47·6 per cent. Gemant considered that 43 per cent was sufficiently close to the mean observed value for an actual soil, for which he quotes a value of 38 per cent.

It is incorrect to suggest that I am unaware of Gemant's later work; I have indeed had some personal correspondence with Dr. Gemant upon these matters. I disagree with those who think it a waste of time to discuss the spherical model, because it is now obsolete. By studying the initial work of Gemant, one can see the reasons for the later modifications, some of which appear to be unnecessary, whereas others, such as the new cubic–pyramidic model, are a severe strain on the credulity of some of us.

The interested reader who turns to Gemant's initial paper[1] will find the following statement (p. 752): "If the present calculations were carried out for oblate ellipsoids, instead of spheres, or for grains bounded partly by planes, the agreement in the low moisture content range might perhaps be improved" (1950). Once again the need to modify the spherical model is related to poor agreement with actual soil data in the low-moisture region, where air conductance plays a large part, which Gemant entirely neglects. Note also the obvious search for a model particle which will, when analysed, yield results which compare favourably with observed data. Is it really surprising, then, that this new particle, composed of a cube with square-based pyramids on three sides, does, when analysed, yield consistent results?

The photomicrographs given in Gemant's later article[3] seem to me to be insufficient evidence upon which to base the case for the new particle.

I have a great respect for Dr. Gemant's singleness of mind in his pursuit of a model particle; but I personally doubt if any useful purpose is served by basing the calculations of the resistivity of soil upon an improbable hypothetical particle, because of the manifest heterogeneity of soil.

I agree with Mr. Makowski that recently there has been an increasing tendency for experimenters to obtain consistent results, due presumably to increasing standardization of methods of analysis; and in this connexion I was much interested in his account[4] of the interesting probe method, which would appear to be the obvious method for finding soil resistivities in the future.

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Non-Coplanarity of the Nitro Group and Rate of Electrophilic Substitution in Nitromesitylene

In 1939, Baddeley[1] presented a brief survey of reactions which might be interpreted in terms of steric inhibition of resonance. Because of the lack of quantitative studies, some of the examples reported there, such as the diacetylation and the "extraordinarily facile" dinitration of mesitylene, could be considered only as suggestive hypotheses. Although no further work has appeared in support of these hypotheses[2], Baddeley's interpretations of the reactions of non-coplanar substituted mesitylenes are still being considered as essentially valid in several text-books. This is surprising, because, first, in a substituted mesitylene further nuclear substitution can only occur *meta* to the 2-substituent already present, with no more than a secondary resonance effect[3,4]; and because in electrophilic substitutions conjugation of electron-withdrawing groups (NO_2, COMe, etc.) with the ring is not enhanced by polarization in the transition state[5].

In an earlier paper[6] on this series of investigations it has been shown that the ease of dinitration of durene in a two-phase liquid system cannot be correlated with the effect of steric inhibition of resonance of the first substituent, although in nitrodurene the site of reaction is *para* to that group, that is, at a position expectedly sensitive to inhibition of resonance. This suggests that care must be taken in drawing any conclusion as to the effects of molecular structure unless the conditions are adjusted to avoid heterogeneity.

We have devised a technique[4] for studying the electronic effects of *meta* and *para* substituents separately by the examination of substituted polymethylbenzenes. The first reaction studied by us, bromination, allowed the determination of a reaction constant $\rho = -8{\cdot}6$, as based on the halogen substituents, to fit a Hammett-type linear equation.

On applying the same technique to the nitro-group of nitromesitylene, it was found that the reactivity k/k_0 of this compound relative to that of mesitylene is $0{\cdot}95 \times 10^{-7}$. Such a value illustrates the very strong deactivation produced by the introduction of a nitro group in mesitylene toward electrophilic substitution. Were the site of reaction sensitive to the operation of steric inhibition of resonance by the *meta*-nitro group to the extent of yielding a qualitative explanation for the ease of dinitration of mesitylene, the reactivity predicted from the Hammett equation should be markedly lower than the observed one. In fact, we find for $(k/k_0)_{calc.}$ a value of $7{\cdot}3 \times 10^{-7}$, that is, somewhat higher than for $(k/k_0)_{obs.}$. In view of the strong electronic effect of the nitro group, the difference is not serious.

It should be emphasized that bromination is a more selective reaction than nitration and, on account of its high reaction constant, is very sensitive to electronic changes at the reaction centre. The present results can then be taken as definite evidence of the absence of any effect of reduced conjugation, due to non-coplanarity of nitromesitylene, on *meta* electrophilic substitution. Finally, it will be noted that whereas the molecular pattern of nitromesitylene is unsuitable to illustrate the phenomenon of steric inhibition of resonance through chemical reactivity, the non-coplanarity of the nitro group in the same substance appears to have been established beyond doubt in dipole moment investigations[7].

The experiments on rate of bromination of nitromesitylene were carried out by the procedure described previously[4]. Details will be reported shortly elsewhere together with the results concerning nitro-*iso*durene and nitrodurene.

This work is a continuation of that described under the title "Substitution in Polymethylbenzenes". Part VI: Grassini, Illuminati and Marino, *Gazz. chim. ital.*, **86**, 1138 (1956).

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Jan. 16.

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Enhancement of the Biological Activity of Sodium Dodecyl Sulphate by Inorganic Cations

In a preliminary investigation of the effect of a number of ionic detergents on the aerobic fermentation of glucose by baker's yeast[1], it was found that sodium dodecyl sulphate ($0{\cdot}002$ *M*) had little effect on the aerobic output of carbon dioxide by a 1/20 suspension of yeast in 5 per cent glucose. Further experiments indicated that the sodium dodecyl sulphate, even when present in $0{\cdot}02$ *M* concentration, only partially inhibited the aerobic production of carbon dioxide by such suspensions. The relationship between concentration of sodium dodecyl sulphate and percentage inhibition of carbon dioxide production is shown in Fig. 1 for detergent concentrations up to $0{\cdot}02$ *M*. It is seen that at no time did the degree of inhibition observed exceed about 40 per cent.

These findings did not seem to accord well with the results reported earlier by Wills[2] for the effect of sodium dodecyl sulphate on the aerobic fermentation of glucose by brewer's top yeast. Using a yeast suspension of about $0{\cdot}6$ per cent in $0{\cdot}05$ *M* phosphate buffer, Wills found that $0{\cdot}001$ *M* sodium

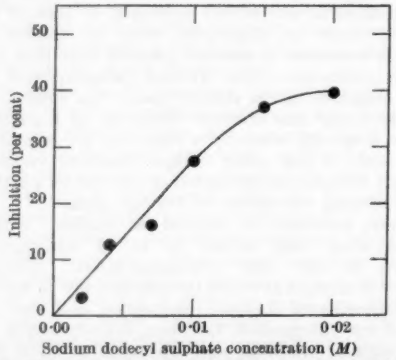

Fig. 1. Effect of sodium dodecyl sulphate on the aerobic production of carbon dioxide by baker's yeast. Yeast suspension; 1 part by weight in 20 vol. of 5 per cent glucose

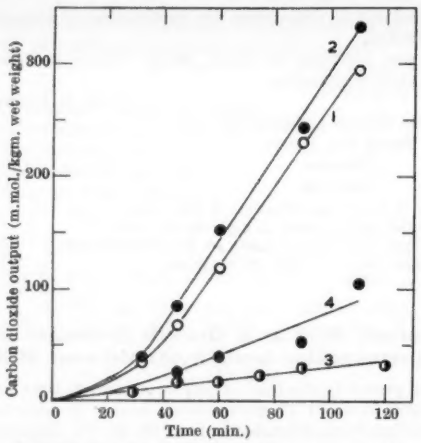

Fig. 2. Effect of sodium dodecyl sulphate on the aerobic production of carbon dioxide by brewer's top yeast. Yeast suspension; 1 part by weight in 20 vol. suspension fluid. Curve 1, 5 per cent glucose; curve 2, glucose + 0·002 *M* sodium dodecyl sulphate; curve 3, glucose + 0·004 *M* sodium dodecyl sulphate; curve 4, glucose + 0·002 *M* sodium dodecyl sulphate + 0·05 *M* sodium chloride

dodecyl sulphate caused virtually complete inhibition of aerobic fermentation, the degree of inhibition falling off fairly sharply with decreasing concentration of detergent. Somewhat later, Wills informed me of essentially similar results with unbuffered suspensions of brewer's yeast.

It now appears that the discrepancy between these results is probably due to the different sensitivity of the two strains of yeast to sodium dodecyl sulphate. Using a strain of brewer's top yeast (Guinness, Dublin), it has been found that whereas 0·002 *M* sodium dodecyl sulphate causes a slight increase in the rate of carbon dioxide output by a 1/20 suspension in 5 per cent glucose (curve 2, Fig. 2), 0·004 *M* sodium dodecyl sulphate gives rise to a very marked inhibition of carbon dioxide production (curve 3, Fig. 2). Concentrations of the detergent in excess of 0·004 *M* practically completely inhibited the production of carbon dioxide by these suspensions.

Discussing his results with brewer's yeast, Wills[2] suggested that inhibition of yeast metabolism by sodium dodecyl sulphate will occur only when the detergent is present in the micellar form. The results shown in Fig. 2 appear to support this hypothesis. The critical micelle concentration of sodium dodecyl sulphate is usually considered[3,4] to be about 0·0065 *M*, and it is of interest to note that the results shown in Fig. 2 indicate that the inhibitory effects of this compound decrease quite sharply at concentrations less than 0·004 *M*, that is, in a concentration-range which is not greatly removed from the critical micelle concentration. It appeared to me that this hypothesis might be tested in another way. It is known[5] that the critical micelle concentration of sodium dodecyl sulphate is decreased in the presence of inorganic salts, this decrease depending only on the concentration of the added cation. The effect on the inhibitory action of the detergent on the carbon dioxide output of brewer's yeast of a number of inorganic salts which do not by themselves inhibit yeast metabolism has, therefore, been investigated. Curve 4 of Fig. 2 shows the production of carbon dioxide by a 1/20 suspension of Guinness yeast in a medium containing 5 per cent glucose, 0·002 *M* sodium dodecyl sulphate and 0·05 *M* sodium chloride. It is seen that there is a marked inhibition of carbon dioxide output. A control suspension containing glucose and sodium chloride only gave results which did not differ significantly from those shown in Fig. 2 (curve 1) for yeast suspended in 5 per cent glucose alone.

In further experiments, which will be published in detail elsewhere, it has been found that the inhibitory effect of 0·002 *M* sodium dodecyl sulphate on the production of carbon dioxide by suspensions of Guinness yeast containing various concentrations of sodium chloride can be related to the total concentration of sodium ions present in a fashion that is strikingly reminiscent of the action of this ion in lowering the critical micelle concentration of the detergent. Similar effects have been obtained with other sodium salts (nitrate, sulphate) and with neutral salts of other cations (lithium, ammonium, magnesium) which are non-toxic to yeast. In the case of sodium ions, the same effect has also been observed, in greater or lesser degree, with a number of other anionic detergents. It seems likely, therefore, that with certain strains of yeast, inhibition of metabolism by anionic detergents will only occur when the latter are present in the system as micellar aggregates.

I wish to thank Messrs. Arthur Guinness, Son and Co. (Dublin), Ltd., for generous supplies of yeast.

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Jan. 11.

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Effect of Alcohols on the Synthesis of Lecithinase by *Bacillus cereus*

A number of strains of *Bacillus cereus* Fr. and Fr. growing in liquid culture synthesize a lecithinase that appears in the external medium[1–3]. While studying the effect of changes of culture conditions on lecithinase synthesis, I observed by chance that the presence of certain alcohols in the growth medium could inhibit formation of lecithinase by the growing cells.

The inhibitory effects of different concentrations of methyl, ethyl, *n*-propyl and *n*-butyl alcohols—four of a number tested—are illustrated in Fig. 1. In this series, the ability to prevent the appearance of lecithinase activity increases with increasing molecular weight. *Iso*propyl alcohol and tertiary butyl alcohol behave in a manner similar to *n*-propyl and *n*-butyl alcohols respectively.

None of these alcohols, in the concentration-range studied, inhibited the activity of a partially purified lecithinase; indeed, 0·5 per cent *n*-butyl alcohol caused a 20 per cent stimulation of activity. Furthermore, the inactive culture supernatant, which resulted from bacterial growth in the presence of alcohol, did not inhibit the activity of added lecithinase. Lecithinase produced in the presence of alcohol, then, would be able to act; and the absence, or lowering, of lecithinase activity indicates an inhibition of lecithinase synthesis.

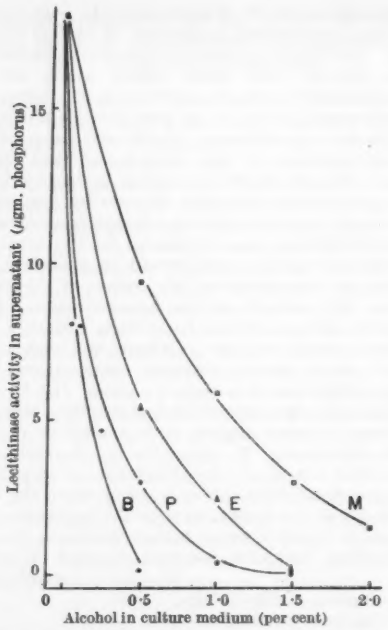

Fig. 1. Effect of alcohols on lecithinase synthesis. Culture tubes containing 20 ml. nutrient broth and alcohols as shown were inoculated with 0·05 ml. of a 5-hr. culture of *B. cereus* (Strain *Mu*-3055) and incubated, standing, for 14 hr. at 37° C. The bacteria were centrifuged down and lecithinase activity of the supernatant was determined in the following system: 0·5 ml. supernatant; 0·1 ml. 0·25 *M* borate buffer, *p*H 7·1; 0·05 ml. 0·1*M* calcium chloride; 0·85 ml. water; 0·5 ml. 2·5 per cent lecithin; 0·2 ml. toluene; 0·2 ml. ethyl ether. After 2 hr. incubation in a glass-stoppered tube at 27° C., 2·0 ml. 5 per cent trichloroacetic acid was added and the increase in acid-soluble phosphorus determined (refs. 3, 4).

M = methyl alcohol; *E* = ethyl alcohol; *P* = *n*-propyl alcohol; *B* = *n*-butyl alcohol

Rates of bacterial growth, as well as the final total amounts of bacteria (measured both by turbidity and by plate counts), were only slightly, or not at all, affected by those concentrations of alcohols shown in Fig. 1; 2 per cent *n*-butyl alcohol completely inhibits growth, as does 0·5 per cent *n*-amyl alcohol.

The above observations were made with bacteria growing in nutrient broth. It was found, in addition, that bacteria growing in a medium containing casein hydrolysate (Nutritional Biochemicals) as carbon and nitrogen source also synthesize lecithinase, and that in this medium lecithinase synthesis is inhibited by alcohols.

Most of the lecithinase formed by growing cultures of *B. cereus* is to be found in the external medium. Whole bacterial cultures, that is, bacterial cultures containing both cells and external medium, usually have, if any, only slightly more activity than cell-free culture supernatants. After growth in the presence of alcohols, whole bacterial cultures are also devoid of lecithinase activity. It does not seem, then, that these alcohols act by preventing the passage of formed lecithinase from within the cell to the external medium. Although relatively high concentrations are required to inhibit synthesis of lecithinase, the alcohols do not act as general cell poisons or metabolic inhibitors, since, in concentrations that completely inhibit synthesis of lecithinase, they do not prevent growth. Further studies are now being carried out to determine the mechanism of the action of alcohol.

I am indebted to Miss Betty White for careful technical assistance.

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Formic Acid as a Growth Stimulant for *Lactobacillus lactis* in Autoclaved Milk

In previous studies[1] it has been shown that *Lactobacillus lactis* O 37 grows much better in autoclaved milk than in milk heated only to 80–90° C. Apparently this is due to the formation in milk, during heating in the autoclave, of a stimulatory substance which results from the decomposition of lactose[2].

To investigate the nature of this substance, a 'dialysate' of autoclaved milk (130° C., 30 min.) was prepared by suspending bags of 'Visking' cellulose tubing containing water in autoclaved milk (100 ml. of water per 2 l. of milk). After 24 hr. of dialysis in the cold, the liquid inside the bags contained the stimulatory substance in the same concentration as in autoclaved milk. This dialysate was passed successively through a column of cation exchange resin, 'Permutite 50', prepared by the method of Moore and Stein[3], and a column of anion exchange resin, 'Amberlite *IRA* 410', prepared by the method of Bryant and Overell[4]. The column of 'Permutite 50' was then eluted with *M* ammonium hydroxide and the column of 'Amberlite *IRA* 410' with 0·5 *M* ammonium carbonate. Only the eluate of 'Amberlite *IRA* 410' was stimulatory: it contained 50 per cent of the stimulatory substance of the dialysate.

The 'Amberlite' eluate was acidified to *p*H 2 and steam distilled. The distillate contained 50 per cent of the stimulatory substance present in the eluate.

This indicates that at least part of the stimulatory substance of autoclaved milk behaves like a volatile organic acid. It is well known that acids are formed in milk during autoclaving. Formic acid represents about 80 per cent of the volatile acids formed and is present in autoclaved milk (116° C., 2 hr.) at a concentration of about 15 mgm. per 100 ml. [5].

A number of substances known to be present in autoclaved milk were examined for their stimulatory activity on *L. lactis* O 37 when added to milk heated to 90° C. Among these substances, formic acid (added to milk as calcium formate) was found the most effective, whereas other organic acids were inactive. Milk heated to 90° C. and containing 15 mgm. per 100 ml. calcium formate has the same activity as autoclaved milk.

These results show that the substance in autoclaved milk which stimulates the growth of *L. lactis* O 37 is most probably formic acid. While other organic acids have been shown to be stimulatory for micro-organisms (acetic acid, lactic acid, pyruvic acid), it seems that formic acid has not hitherto been shown to be a growth stimulant. It is possible, however, that formic acid is sometimes responsible for the stimulation which is often observed in culture media autoclaved in the presence of reducing sugars,

stimulation which is generally considered to be due to heat degradation products of these sugars[6].

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Immunization against *Ascaris lumbricoides* in the Guinea Pig

Numerous attempts have been made in the past to produce a satisfactory immunity against nematodes by the use of extracts and suspensions of living and dead parasites[1]. The almost universal finding has been that any immunity so produced was much inferior to that occasioned by active infection. The available evidence indicates that the use of preparations of whole organism, as in the general techniques of bacterial vaccination, is inapplicable to helminth infections. Furthermore, the excretory and secretory products of helminths appear to play a vital part in immunization[2], and consequently it would appear that actively metabolizing helminths are necessary within the host before substantial 'protective' immunity can be induced.

Present work with *A. lumbricoides* has indicated that 'protective' immunity comparable to that produced by normal infection can be achieved if the time and route of the migratory phase are altered. This is induced by the subcutaneous injection of embryonated and infective ova so that a depot of viable eggs is formed; a minority of these hatch to liberate larvæ that wander locally in the tissues, and a few undergo a delayed migration to the lungs. Numbers of eggs substantially in excess of the lethal dose by the oral route can be thus administered to guinea pigs.

A group of guinea pigs was immunized subcutaneously with 50,000 infective ova on two occasions at an interval of twenty days. A similar group was given 20,000 infective ova orally at the same time-interval. Twenty days after the last infection, these guinea pigs, along with a control group, were challenged with 100,000 infective ova given orally. Representatives from each group were killed daily from the first day after challenge until the eighth day. The numbers of larvæ in the liver and lungs of the animals were counted, and the larvæ were measured.

Fig. 1 indicates that the rate of migration in the immunized groups was greatly depressed from the normal marked migration which occurred between the third and the sixth day after infection. Enhanced migration was observed in the first few days in the guinea pigs given ova subcutaneously. Fig. 2 shows that little growth occurred in the larvæ in either of the immunized groups.

The number of larvæ present in both the immunized groups on the eighth day was small, and

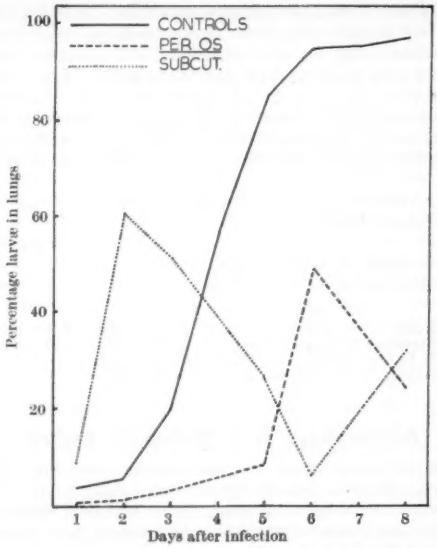

Fig. 1. Migration of larvæ derived from a challenge infection of 100,000 ova *per os* in control guinea pigs and in guinea pigs immunized by the oral and subcutaneous administration of *Ascaris* ova

all showed evidence of marked degeneration. Many were covered with precipitates and cellular masses.

Subsequent experiments with non-viable 'vaccines', as distinct from the viable preparations used above, have indicated that a saline extract of disintegrated infective ova and a saline solution of larval excretions and secretions are the most potent preparations for stimulating protective immunity. The extract of infective ova was given subcutaneously on three occasions and resulted in a 50 per cent depression of migration and a 45 per cent depression of growth

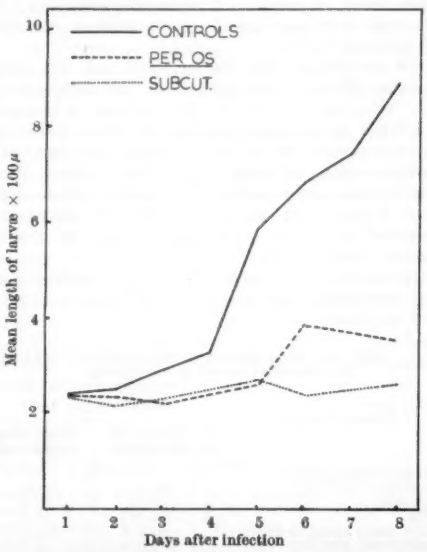

Fig. 2. Size of larvæ derived from a challenge infection of 100,000 ova *per os* in control guinea pigs and in guinea pigs immunized by the oral and subcutaneous administration of *Ascaris* ova

of the larvæ from a challenge infection. The preparation of larval excretions and secretions was given subcutaneously on six occasions and resulted in a 28 per cent reduction of migration and a 25 per cent reduction of growth of larvæ from a challenge infection. With both these preparations, some degree of enhanced migration of larvæ was noted within the first few days of infection with the challenge dose of ova.

A further account of these experiments will be published elsewhere.

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Actinophage as a Mutagenic Factor

It is known that the actinophage destroys only those cells that possess specific sensitivity to it. Cells which survive form colonies with a changed structure of the surface and acquire a number of new physiological properties[1].

To investigate the mutagenic ability of the actinophage, it was necessary to compare two processes of mutation, one induced by ultra-violet or X-rays and the other taking place under the action of the actinophage. The *N*-6 strain of *Actinomyces olivaceus* was used in all tests. Actinophage was isolated from a culture of *Str. griseus* (*Actinomyces globisporus streptomycini* as determined by Prof. Kracilnikov) and was marked No. 1. The culture undergoes an effective lysis caused by the actinophage under the conditions of submerged growth.

The spores of *Actinomyces olivaceus* were inoculated into 250-ml. Erlenmeyer flasks containing 50 ml. of broth consisting of corn steep liquor (1·0 per cent), ammonium sulphate (0·5 per cent), calcium carbonate (0·5 per cent), 'Hydrol' (1·5 per cent), starch (1·0 per cent), and were incubated on a shaker at about 250 r.p.m. at 28° C.

After incubation for 24 hr., 0·5 ml. of phage-containing filtrate was added to the fermentation flasks. After the next 24 hr. the contents of the flasks were plated on an agar medium in Petri dishes and were incubated at 28° C. After seven days incubation the dishes were examined and the counts of the changed forms were made. The typical colonies (the normal forms) and the new, changed forms were transferred to slants, and final counts of induced mutations were made.

As a control, the same culture but without any phage treatment was plated. The results are presented in Table 1.

Table 1. Rate of Morphological Mutations of Strains of *Act. olivaceus* induced by Actinophage 1

Types of colonies	Mutations (per cent)	
	Without any treatment	Under phage treatment
Dark grey well-sporulated (typical)	97·9	11·5
Light grey	0·65	20·8
White	0·75	35·5
Yellow (badly sporulated)	0·0	16·1
Bright lemon, film-like	0·0	12·3
Brown (smooth)	0·0	3·0
Non-sporulated	0·72	0·70

Alongside the above-mentioned experiment, spores of the same strain (*Act. olivaceus*, *N*-6) were treated with ultra-violet radiation.

Mutations occurring under the influence of the ultra-violet rays resembled those occurring after phage treatment, but ultra-violet produces a much slower rate of mutation. The maximum rate of mutation induced by ultra-violet radiation within the range of 500–4,000 ergs/mm.^{2} was 13·5 per cent. These results show that the actinophage is a strong mutagenic factor.

The rate of mutation induced by the phage reaches 90 per cent and consequently it is many times higher than that induced by ultra-violet radiation.

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A Sex Difference in Morphology of Neutrophils in the Dog

A structural difference has been described between the nuclei of neutrophil leucocytes in the male and those in the female in humans[1–5] and in rabbits[6].

Recently, during the course of marrow transplantation experiments in irradiated dogs, search was made for a biological cell marker characteristic of the donor which would be identifiable in the host. The possibility of a sex difference in dogs' blood analogous to that seen in man was considered and investigated.

Blood films were stained by Wright's method and the neutrophils were examined in each of a series of 100 preparations, 50 of which were taken from dogs and 50 from bitches. At the time of examination the sex was not known to the examiner.

In the blood films from bitches, characteristic 'drumsticks' could be recognized in a proportion of the neutrophils (Fig. 1). These had the same appearance as those seen in humans, each consisting of a well-defined, solid, chromatin nodule about 1·5μ in diameter, joined by a single fine chromatin strand to one lobe of the nucleus. They occurred on the average once in every twenty-two neutrophils; before accepting a blood film as being from a female, six neutrophils showing these discrete solitary nodules had to be found. Occasionally the nucleus of an eosinophil would show a similar chromatin mass.

Most of the neutrophils in blood films from dogs showed nothing resembling a true drumstick. Occasionally, however, minor lobes and sessile nodules caused confusion on superficial examination.

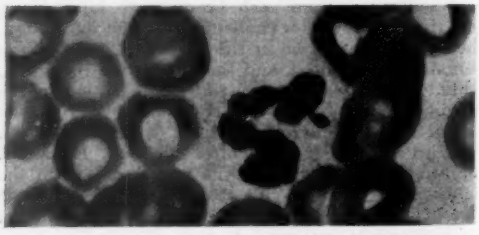

Fig. 1. A female neutrophil leucocyte showing a characteristic drumstick joined to the lobed nucleus by a thin strand of chromatin (Wright's stain). (× 1,750)

Small chromatin clubs, often multiple, were fairly frequent. At first 500 neutrophils were examined without finding a typical drumstick before concluding the film came from a male. Later, it was found sufficient to examine only 300 neutrophils.

As in humans, drumsticks were rarely found in immature neutrophils.

In none of these 100 films in which the sex was not known to the examiner was there an error in detecting the sex.

The findings reported here indicate that an accurate diagnosis of sex in the dog can be made by a study of the morphology of the neutrophils in blood films.

It follows that if marrow from a bitch is injected into an irradiated male, survival and proliferation of the donor cells in the host will be implied if neutrophils bearing characteristic drumsticks can later be identified in the host's peripheral blood and marrow.

Such studies are now being carried out and will be reported in detail later.

The help and encouragement of Dr. Francis D. Moore and Dr. H. Meier are gratefully acknowledged.

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A Sex Difference in the Chromatin Structure of the Peripheral Blood Lymphocytes

SINCE Barr and Bertram[1] in 1949 described the detection of the so-called sex chromatin in intermitotic nuclei a large number of investigations has been carried out in this field. Davidson and Smith[2] in 1954 showed the presence of sex-specific nuclear appendages in granulocytes of the peripheral blood. Apart from these investigations on granulocytes, the detection of a sex difference in intermitotic cells has been based on the criteria outlined by Barr and his co-workers.

In certain animal species as a whole and in certain isolated types of tissues, a cellular sex difference could not be detected (for review see ref. 3). This is due to the occurrence of multiple chromatin condensations in identical cells from the two sexes. These condensations seem to mask the presence of a possible sex-specific nuclear condensation.

The lymphocytes of peripheral blood represent an example of such pachychromatic cells in the human, in which a sex difference cannot be detected by using the common morphological criteria for sexing nuclei. It is possible, however, that the mere presence of sex chromatin and its morphological variations are related to the intranuclear protein metabolism and are linked through this to major changes in the cellular morphology during a differentiation process.

In accordance with this hypothesis, the lymphocytic cells from peripheral blood were examined in regard to the eventual presence of a sex difference after an initial process of cellular differentiation had taken place. The technique used included a 24-hr. incubation of the 'buffy coat' from peripheral blood in a homologous plasma coagulum in accordance with the principles of Carrel[4]. This incubation was followed by fixation and preparation as indicated by Moore and Barr[5].

Blood from a total of twenty-three persons was examined, eleven females and twelve males. Three samples from each person were prepared. In sixteen of the persons examined, one or more of the final preparations showed considerable differentiation of the incubated lymphocytic cells. This was indicated by a change in cellular size and delineation. The cellular morphology was evidently identical with that of the macrophages and fibroblasts of connective tissue. The chromatin structure in different stages between the lymphocytes of the peripheral blood and their derivatives was studied. It was shown in this way that the intranuclear differentiation followed a regular pattern.

In lymphocytic cells from both sexes the dense masses of chromatin were dissolved or split into minor pieces, which were located peripherally in contact with the nuclear membrane. In lymphocytic cells from males, these chromatin condensations gradually diminished in size and ultimately often disappeared almost completely. If a dissolution into particles of almost submicroscopic size did not take place, the condensations left were nearly always multiple. In lymphocytic cells from females, the changes initially ran parallel to those seen in male cells. In the late stages, however, a single peripherally located nuclear body was often noticed in female lymphocytic cells. This nuclear body was morphologically like the 'sex chromatin' in epithelial nuclei and was larger than the nuclear condensations in male cells. The incidence of this female nuclear body was much lower than that of 'sex chromatin' in epithelial cells. In spite of this, a morphological sex difference was very distinct. Based on examinations of the lymphocytic cells, a correct sex diagnosis could thus be established in all cases (16 out of 23) in which the incubation experiment gave rise to a satisfactory degree of cellular differentiation.

In samples where the cells formed a single layer and in which all phases of the preparation were optimal, a central vacuole in the sex-specific chromatin was noticed, in accordance with the finding of Prince *et al.*[6].

The detection of a sex difference in the lymphocytic cells from peripheral blood has only theoretical interest. The investigation shows that a sex difference under certain conditions can be 'unmasked' in cells, in which such a detection is impossible when routine methods for cellular sexing are applied. This finding suggests that changes in cellular activity and probably morphology should be induced, if possible, in the theoretical study of sex chromatin in certain animal species and in certain types of tissue. In this way a 'hidden' sex difference might possibly be detected. Probably the criteria for sex diagnosis should also be changed.

POVL RIIS

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Tetraploid Varieties of *Sorghum vulgare*

Plant breeders producing new sorghum varieties for use by peasants in relatively under-developed areas are faced with the problem that such varieties may quickly disappear, through crossing with the local unimproved types.

All the grain sorghums are diploid ($2n = 20$) and an obvious way to avoid contamination would be to develop tetraploid strains. Such strains might well possess other advantages, such as increased grain-size, and greater vigour of the plant as a whole. So far as I am aware, no attempt has been made to develop tetraploid sorghum varieties for general cultivation. Chin[1] reported that the relative sterility of polyploid sorghums made them of doubtful economic value: he also found that the autotetraploid strains flowered twenty days later than the corresponding diploids.

Very many varieties of *Sorghum vulgare* exist in Africa and Asia; crosses between such varieties are fertile and exhibit varying degrees of hybrid vigour. Geographical isolation has probably led to the development of local races of cultivated sorghums[2]. It is possible that sufficient differentiation of the genomes may have taken place for preferential association to occur when more than two genomes are present, so that a degree of alloploidy could be obtained. Figures are not yet available for material of very different origins, but results from fairly closely related strains suggest that there are good prospects of obtaining sufficiently fertile tetraploid sorghums to be of practical value.

Autotetraploids were made from two strains, *A* and *B*, by doubling with colchicine. Both strains are derivatives of first backcrosses, selected for the earliness and plant type of the recurring parent, combined with the grain types of the non-recurring parents. 27 *UT* from the Belgian Congo was the recurring parent in both cases: the non-recurring parent of *A* was Wiru from the Lake Victoria area of Tanganyika: and that of *B* was Msumbiji from the southern coastal belt of Tanganyika.

The general vigour of the autotetraploids is good: the straw is shorter and stouter than that of the corresponding diploids, but the length of maturity is similar.

The F_1 and F_2 generations from the cross (autotetraploid $A \times$ autotetraploid B) gave a decidedly better seed-set than that of the parents (see Table 1).

These are preliminary figures, from plants grown late in the season (columns 2, 3 and 5) and in the greenhouse (columns 1 and 4), but the general comparisons should be valid. The diploid in column 5 is not the identical cross, but all the sorghum diploids here are fully fertile.

Table 1. Seed-set as a Percentage of the Total Number of Sessile Spikelets in the Panicle

Column	1	2	3	4	5
Class (per cent set)	4*n* Parent *A*	4*n* Parent *B*	4*n* Cross $A \times B$, F_1	4*n* Cross $A \times B$, F_2	Diploid
0–9·9	4	—	—	—	—
10–19·9	3	3	—	2	—
20–29·9	3	7	—	0	—
30–39·9	6	5	1	2	—
40–49·9	1	5	0	1	—
50–59·9	2	—	5	3	—
60–69·9	2	—	13	6	—
70–79·9	—	—	18	17	1
80–89·9	—	—	—	33	10
90–99·9	—	—	—	—	9
Arithmetic mean (per cent)	31	31	68	74	88

The distributions and amounts of seed set in the F_1 and F_2 generations from the tetraploid cross resemble those of the diploid more closely than do those of the autotetraploid parents, which suggests a degree of alloploidy. If this interpretation is correct, it should be possible to work out the relationship of sorghum varieties from crosses between their tetraploids. Even if cytological studies show that some other mechanism is involved, there are still prospects that the advantages of 'hybrid sorghum' may be obtained without the complications involved in producing hybrid seed.

The work will be published elsewhere at a more advanced stage, but the potentialities of tetraploid sorghum seem sufficiently interesting to justify presenting these preliminary results. I am indebted to the Director of Agriculture, Tanganyika, for permission to publish this communication.

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Dec. 4.

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Relationship between some Coastal Fauna and Arthropod-borne Fevers of North Queensland

Following on an outbreak of dengue fever in Townsville, North Queensland, in the early months of 1954, O'Connor *et al.*[1] found that the sera of some members of species of flying foxes (genus *Pteropus*) gave positive protection tests against the dengue type 1 (Hawaiian) strain. At the same time sera were collected from locally migratory birds, the black duck (*Anas superciliosa*) and grey teal (*Querquedula gibberifrons*), which mainly frequent the inland swamps, and also from wading birds (Charadriiformes) along the sea shore. These latter are found on the mudflats and sandpits, which are often in close proximity to the mangrove swamps where the flying foxes camp during daylight hours.

The birds trapped included two locally migratory in Australia, the redcapped dotterel (*Leucopolius alexandrinus ruficapillus*) and a silver gull (*Larus novae-hollandiae*). This latter belongs to the order Lariformes and was a young bird captured on foot because it was paralysed in both legs and one wing. The others trapped migrate during the antipodean winter to sub-arctic regions in the vicinity of Siberia to breed. They belong to the Charadriiformes and consisted of rednecked stints (*Calidris ruficollis minuta*), sharptailed sandpipers (*C. acuminata*) and greytailed tattlers (*Heteroscelus brevipes*).

This work was prompted by the reports of various authors of evidence of infection in birds by some members of the arthropod-borne viruses such as Japanese *B* encephalitis[2], and Murray Valley encephalitis[3], which are immunologically related to the dengue fever group.

The birds of the seashore were selected because dengue is primarily a coastal disease[4], and also because

Table 1

Serial No.	Species	Deaths in mice*
1	Rednecked stint (*Callidris ruficollis minuta*)	5/6
2	" " " " " "	5/6
3	" " " " " "	4/6
4	" " " " " "	5/6
5	" " " " " "	4/6
6	" " " " " "	2/6
7	" " " " " "	1/6
8	" " " " " "	4/6
9	" " " " " "	5/6
10	" " " " " "	0/6
11	" " " " " "	0/6
12	" " " " " "	1/6
13	" " " " " "	2/6
14	" " " " " "	2/6
15	Sharptailed sandpiper (*C. acuminata*)	2/6
16	" " " " "	5/6
17	" " " " "	0/6
18	Greytailed tattler (*Heteroscelus brevipes*)	0/6
19	Redcapped dotterel (*Leucopolius alexandrinus ruficapillus*)	2/6
20	" " " " "	5/6
21	" " " " "	0/6
22	Silver gull (*Larus novae-hollandiae*)	0/6
23–35	Black duck (*A. superciliosa*)	5/6–6/6
36–38	Grey teal (*Q. gibberifrons*)	6/6

* Numerator indicates the number of mice dead at the end of the test; denominator indicates the number of mice inoculated. Deaths in the first 48 hr. are discounted.

Those tests in which 5 out of 6 mice survived were taken as presumptive evidence of the presence of protective antibody; those in which none or one survived were regarded as negative, and those in which 2, 3 or 4 survived were looked on as inconclusive.

of the observation of Hamlyn-Harris[5] that there is an association between the occurrence of epidemics of dengue fever in Australia and in the Far East. The evidence for the latter was slender, but in view of the fact that the migrant waders traverse these territories in their annual trans-equatorial movement, it was thought worth following up.

The sera of these birds were subjected to mouse protection tests against the dengue 1 (Hawaian) virus, using a challenge dose, as determined by parallel virus titration, of at least 50 *LD*50 by intracerebral inoculation of 14-day old white mice. The results are set out in Table 1 and indicate that the sera of the duck and teal were negative. Of the twenty-four sera from the seashore birds, those of the gull, one dotterel, four stints, one tattler and one sandpiper were positive.

An attempt to extend these results in December 1955 failed because of inability to trap any sea birds. However, sera from twenty-eight flying foxes were collected and subjected to protection tests as before, using as challenge viruses: dengue 1, dengue II (New Guinea), Murray Valley encephalitis, Japanese *B* encephalitis and West Nile fever viruses. The results are recorded in Table 2. Three sera were positive with dengue I, inconclusive with the dengue II and negative with the other three viruses. One serum was positive with the dengue II, inconclusive with the dengue I and negative with the other three viruses. Four were positive with the Murray encephalitis virus; all these were negative or inconclusive in both dengue viruses. One of these was positive with the Japanese *B* virus and inconclusive with the other three viruses: another was positive with the West Nile and Japanese *B* viruses and negative with the dengue strains.

Table 2

Serial No.	Species	Challenge virus				
		Dengue I	Dengue II	Murray Valley enceph.	Jap. *B.* enceph.	West Nile fever
1	*Pt. scapulatus*	1/6*	3/5	6/6	6/6	5/6
2	" "	1/6	4/6	6/6	6/6	3/6
3	" "	5/6	4/6	1/6	2/6	6/6
4	*Pt. gouldi*	3/6	4/6	0/6	0/6	2/6
5	" "	6/6	5/6	1/6	1/6	3/6
6	" "	5/6	5/6	0/6	1/6	1/6
7	" "	4/6	0/6	6/6	6/6	6/6
8	" "	1/6	3/6	6/6	6/6	6/6
9–26	*Pt. gouldi*: Negative or inconclusive with all viruses					
27–28	*Pt. scapulatus*: Negative or inconclusive with all viruses					

* Numerator indicates the number of mice dead at the end of the test; denominator indicates the number of mice inoculated. Deaths in the first 48 hr. are discounted. Results are read as in Table 1.

Mouse protection tests can only be regarded as being more convenient, rapid and economical than the more specific neutralization test for a preliminary survey, and are subject to disturbances by non-specific results, variations in the challenge dose administered with various viruses and by immunological cross-relations. The results are, however, taken as indicating that the observations of the older authors concerning the coastal distribution of dengue fever and the probable trans-equatorial relationships, coupled with the findings of modern investigators in kindred fields, show that investigation by modern virological methods of coastal fauna may be fruitful in the study of the epidemiology of dengue.

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A Sea-Anemone from Brackish Water

During the past century, a series of brackish lagoons was established by storm action along the east coast of England at Shinglestreet, near Ipswich. There are eight lagoons of varying sizes, one of which is now dry, along the two miles immediately south of the River Ore. Although only the most northerly opens into the sea, all except the southernmost lagoon are tidal to some extent. In this last one a small white sea-anemone occurs abundantly in the fine bottom mud: more than a hundred specimens were obtained during one visit in November. The anemone appears to be *Nematostella vectensis*, an Edwardsid described by Stephenson[1] and so far recorded only from the Isle of Wight. Among other features, it is characterized by the presence of nematosomes—small round bodies packed with nematocysts—which circulate freely in the cœlenteron or rest near the insertion of mesenteries in the body wall. They are seen in the accompanying photographs and form an unusual feature of considerable interest. Their origin is unknown.

The nematosomes are roughly spherical and vary in diameter from about 15μ to 45μ. In different specimens they may be abundant or rather scarce: it is particularly when they are present in large numbers that they seem to circulate continuously. This movement appears to be due to the cilia covering the mesenteries rather than to any activity of the nematosomes themselves, since inert particles accompany these bodies and all follow a fairly regular

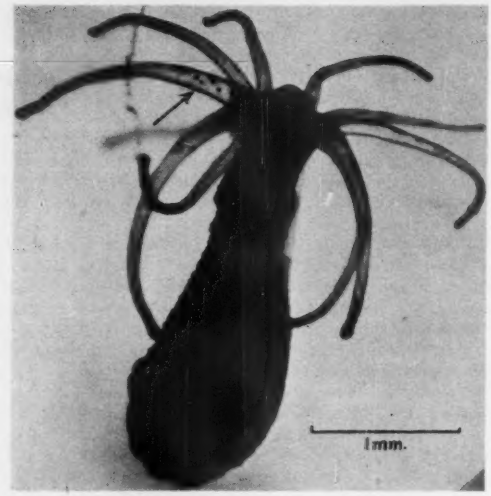

Fig. 1. Small *Nematostella* in transmitted light, with a few circulating nematosomes indicated by arrow

route in the cœlenteron. In general, the nematosomes pass towards the foot along the free median edge of the mesenteries, and return towards the tentacles peripherally, between the mesenteries. They may also be thrown up into the tentacles (see Fig. 1); but they are carried only a short distance before returning, and may thus undergo a rapid juggling motion every few seconds. It is possible that nematosomes play a part in feeding reactions analogous to that of acontia in other sea-anemones, but further observations are needed to throw light on their function.

Salinity measurements obtained so far show that Lagoon 0 varies from at least 1·56 to 1·98 per cent sodium chloride. In the Isle of Wight, *Nematostella* could withstand variations between 0·85 and 3·77 per cent sodium chloride[1]. There appears to be much in common between the two habitats, and it will be interesting if *Nematostella* is found in similar localities elsewhere in Britain. I should be glad to receive any further information concerning the occurrence of this species.

I wish to thank the Wardens of Flatford Mill Field Centre for providing facilities to visit Shinglestreet, and Mr. P. Lockwood for some salinity measurements.

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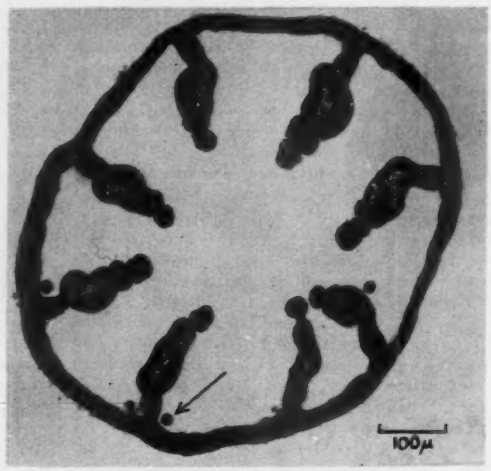

Fig. 2. Transverse section of column, with nematosomes near mesentery base indicated by arrow

[1] Stephenson, T. A., "British Sea Anemones, II" (Ray Society, 1935).

Ecological Separation of Species in *Coelopa* (Diptera, Insecta)

The taxonomic relations of the genus *Coelopa* have hitherto not been very clear; besides *C. pilipes*—a species well characterized—*C. parvula*, *C. frigida* and *C. eximia* were differentiated. It was not clear whether or not these forms really represented well-defined species. Generally each of them was considered a species, but Hennig[1] makes all three varieties of one species (*C. frigida*), as no clear structural differences are found. By rearing experiments I was able[2] to prove that these forms are only modifications of one species and can be obtained by feeding the larvæ with large or small quantities of food respectively. These results seemed to clear up the taxonomic relations of *Coelopa*.

New difficulties arose in further rearing experiments with *Coelopa frigida* from the Baltic (Kieler Förde). The populations from the Baltic and from the North Sea (Heligoland) differ in the following ecological and biological points. The larvæ of the Heligoland population live in banks of seaweed on the seashore; they need for food brown algae (for example, *Fucus*) and animal protein (dead fish or crabs). For copulation, the adult flies need a relatively large container (at least 20 cm. × 20 cm. × 30 cm.), otherwise no eggs, or unfertilized eggs, are laid.

The larvæ of the Kiel population also live in banks of seaweed as well; they need for food algae (red, green, or brown; probably even *Zostera*, Angiospermae, will suffice), but no animal protein. For copulation only small containers are needed (diameter 20 cm., height 5 cm.).

Attempts were made to cross specimens of the two populations, but without success. Therefore it seemed obvious that these populations represent two different species. But I was unable to find structural differences which would allow differentiation without rearing.

Modern definitions of species would permit the use of different names for these 'species'. But since there are no structural differences, I prefer not to do this. I prefer only to direct attention to those most interesting forms, which seem to have no structural, but solely ecological and biological differences. The experiments are being continued.

I wish to thank Dr. K. Strenzke, of Wilhelmshaven, for a careful examination of the structure of specimens of the two populations.

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der Universität,
Kiel.
Jan. 12.

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Preservation of *Nitrosomonas*

It is well known that the isolation of *Nitrosomonas* in pure culture is rather difficult; another problem is how the pure cultures can be successfully preserved. *Nitrosomonas* seems to be more frail than most other bacteria when in pure culture, and unfortunately the majority of strains isolated during past years have been lost.

There is not much information in the literature regarding the means by which cultures of *Nitrosomonas* have been preserved, but it seems probable that most workers have kept their isolates simply by regularly transferring material into fresh liquid media the composition of which has not deviated essentially from the original ammonium medium of Winogradsky. Kingma Boltjes, however, who made a comprehensive study of nitrification in the 'thirties[1], kept his isolates of both *Nitrosomonas* and *Nitrobacter* on agar slants with ammonium sulphate and sodium nitrite respectively, and enriched with 0·5 per cent 'Nährstoff Heyden' (this preparation is no longer available). As the bacteria became accustomed to laboratory conditions, this method of preservation worked satisfactorily if subcultures were made every three to four months (personal communication). Unfortunately, Kingma Boltjes lost all his cultures of nitrifying bacteria during the Second World War. Of more recent isolations, all subcultures of the strain of *Nitrosomonas europaea* isolated by Jensen in 1949[2] have died in spite of approximately monthly subculturing in liquid mineral medium during three years. Even the strain of *N. europaea* isolated by Meiklejohn[3] in 1949 has been lost. Three subcultures of this strain were alive as late as in 1952 (although in the meantime contaminated with other bacteria). At this time the cultures were partly freeze-dried, partly inoculated into sterilized soil and kept at 4° C.; after having been left in this state for eighteen months, all the cultures were dead (personal communication).

In this Laboratory an experiment was initiated more than two years ago in order to compare different methods of preservation of *Nitrosomonas*. The methods were:

(1) Monthly transfers in a liquid medium (5 ml. in test-tubes) of the following composition:

$(NH_4)_2SO_4$	0·4 per cent (w/v)
KH_2PO_4	0·025 per cent (w/v)
$MgSO_4.7H_2O$	0·0125 per cent (w/v)
NaCl	0·0125 per cent (w/v)
$FeSO_4.7H_2O$	0·0025 per cent (w/v)
$MnSO_4.4H_2O$	0·0025 per cent (w/v)
$CaCO_3$	*c.* 0·05 gm. per 5 ml. of medium
Tap water	

*p*H in autoclaved medium 8·0. Size of inoculum one drop 0·03–0·05 ml. of a one-month old culture. Incubation at 25–28° C.

(2) Preservation under a layer of sterile paraffin oil. The same medium was used. After inoculation the cultures were covered with 5 ml. of sterilized oil without previous incubation. Storage at room temperature.

(3) Preservation in sterile soil. A sample of garden soil was slightly moistened with the medium described above, dried in the air, and 10-gm. portions distributed in Freudenreich flasks. The media were autoclaved at 120° for 90 min. and finally inoculated with 0·5 ml. of an actively nitrifying culture. Storage at room temperature.

(4) Freeze-drying of six-weeks old cultures. The ampoules were stored at 0° C. (The freeze-drying was kindly carried out by Dr. Alice Reyn, State Serum Institute, Copenhagen.)

Table 1. Nitrite Production by *Nitrosomonas* after Storage for Various Times in Different Media

Months	Pure culture				Mixed culture			
	Preservation medium							
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
1	+++	+++	++	−	+++	+++	++	−
3	+++	+++	−		+++	+++	−	
6	+++	+++			+++	+++		
12	+++	+++			−*	++		
25	−†	−				−		

Nitrification was not continued in subculture:
* after 11 months.
† after 13 months.

Two strains of *Nitrosomonas* have been used for these experiments: (*a*) a pure culture of *N. europaea* (Lees strain), and (*b*) a natural mixed culture of *Nitrosomonas* sp. and three heterotrophic microorganisms, namely, *Hyphomicrobium vulgare* and two species of *Pseudomonas*[4].

At intervals material from the stock cultures was transferred to fresh liquid medium, and nitrite production in the latter determined after about two weeks of incubation. If no nitrite was detectable at this time, incubation was continued up to five weeks. Cultures giving no nitrite reaction with Griess reagent at the end of the incubation period were regarded as dead. The results are given in Table 1.

The two strains of *Nitrosomonas* showed almost the same reaction to the four methods of preservation. Freeze-drying proved to be of little value, as subcultures failed to show any nitrification after only one month of storage. Probably the bacteria died during the actual freezing process. Likewise sterile soil gave disappointing results. Substances toxic to *Nitrosomonas* are apparently produced when soil is autoclaved, as unsterilized air-dried soil is known to retain its nitrifying capacity for several years. Preservation by monthly transfers and storage under oil gave essentially the same results. Hence it seems that *Nitrosomonas* might be preserved under paraffin oil. This method has the advantage that the risk of contamination is small compared with the method of regular transfers. Although promising, the paraffin oil method is by no means perfect. It is possible that the number of cells initially present was too small, as the cultures were covered with the oil immediately after inoculation without allowing further growth after the oxygen dissolved in the media had been consumed. Experiments with the paraffin oil preservation method are being continued.

The factors controlling ageing and death of bacteria under otherwise non-toxic conditions are little understood. The frequently observed sudden death of *Nitrosomonas* in liquid media is usually not caused by exhaustion of substrate or oxygen. It has been suspected that accumulation of nitrite might have killed the bacteria; but *Nitrosomonas* is known to tolerate considerable quantities of nitrite although this is toxic to many organisms. A possible explanation might be that lethal mutations occur or that a phage interferes.

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Lyngby, Denmark. Jan. 9.

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Systemic Effect of Dieldrin on the 'Body Louse' of Poultry

Systemic administration of parasiticides has been the subject of sporadic research for several decades but has only recently gained prominence in veterinary thought. Successful results have been reported with *Cimex lecticularis*[1,2], *C. hemipterus*[2], *Aedes aegypti*[1], *Ornithodorus moubata*[1], *Boophilus microplus*[3], *Hypoderma lineatum*[4,5], *H. bovis*[4] and *Haemotobia irritans*[6,7]. All the foregoing insects suck blood, or come in close contact with the host's tissues or fluids. This communication describes experiments showing a powerful systemic effect against the biting louse of poultry, *Eomenacanthus straminous*, which has no such close contact with the host's tissues.

Dieldrin was administered orally, subcutaneously or percutaneously (at the base of the neck) at doses of 25, 20, 15, 10 and 5 mgm./kgm. body-weight as a 20 per cent w/v solution ('Dielfly 20', William Cooper and Nephews). Groups of four birds received the largest dose (25 mgm./kgm.) and groups of five birds the smaller doses; the control group comprised fifteen birds. All birds in the experiment were randomly distributed among a population of 480 birds in battery cages. The degree of infestation by lice was classified visually and given a numerical grading according to the density of the population around the vent, which appeared to be the only important site affected. All birds were classified the day before administration of insecticide, and at intervals thereafter. The figures shown in Table 1 are averages of the scores allotted to individual birds in each group.

It can be seen from Table 1 that dieldrin had a powerful systemic effect upon the lice by all routes of administration, but the percutaneous route appeared to be the most effective. Most birds were carrying a heavy burden of eggs when treated. Lice hatched from these eggs and were rapidly killed. Treated birds were also continuously exposed to infection from those in neighbouring cages, but as shown in Table 1 they remained practically free from infestation. These facts show that dieldrin had a considerable residual effect.

It seems that oral treatment of infected birds by mixing dieldrin, or some other systemically active insecticide, with the food may constitute a simpler and more economic method of treatment than the current methods of dusting or spraying. The oral method of administration is now being investigated under various systems of management. If it does not prove satisfactory, the percutaneous method will be further examined, as it would be more efficient than present methods of treatment.

Table 1. Action of Dieldrin on Natural Infestations of Chicks with *Eomenacanthus stramineus*

Route	Days after treatment	Dose rates in mgm./kgm. body-weight				
		25	20	15	10	5
Oral	0	3·3	2·8	3·6	3·6	4·0
	1	0·0	0·0	0·2	1·4	2·0
	3	0·0	0·0	0·0	1·0	0·8
	7	0·0	0·0	0·0	1·0	0·8
	38	0·0	0·2	0·0	0·8	1·2
Percutaneous	0	3·3	3·2	3·8	3·6	3·8
	1	0·3	0·0	0·6	1·2	0·8
	3	0·0	0·0	0·0	0·0	0·2
	7	0·0	0·0	0·0	0·0	0·0
	38	0·0	0·0	0·0	0·0	0·8
Subcutaneous	0	3·8	3·8	3·4	3·6	3·0
	1	1·6	2·8	2·4	2·4	1·8
	3	0·0	0·2	0·2	1·4	1·0
	7	0·0	0·0	0·0	1·0	0·8
	38	0·0	0·0	0·0	0·4	0·8

The average score of the control group varied between 2·2 and 3·2 throughout the experiment.
The degree of infestation was classified as follows: 1, very light; 2, light; 3, light medium; 4, medium; 5, heavy.

I wish to acknowledge the assistance and co-operation of Mr. G. McBride and Prof. J. Francis in this work. Acknowledgment is also due to the Rural Credit Development Fund of the Commonwealth Bank of Australia, which has supplied the facilities for this work.

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Jan. 11.

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Long-distance Migration of Salmon

Details have recently been received of the recapture of a salmon, tagged in Scotland, on the south-west coast of Greenland. This fish was one of a number impounded at Loch na Croic, Blackwater River, Conon District, Ross-shire, during the autumn of 1955, to provide eggs for the hatchery operated by the North of Scotland Hydro-Electric Board at Contin. After stripping, it was tagged and released on November 23, 1955. It was recaptured in Eqaluq Fjord, south of Sukkertoppen, Greenland (64° 56½′ N., 52° 02′ W.), on October 15, 1956.

This recapture is of particular interest for two reasons. First, the distance travelled between tagging site and recapture site (about 1,730 miles) is one of the longest on record; and, secondly, the site of recapture may well be an important hint about the sea migrations of salmon from Scottish rivers. Virtually nothing is known about salmon between the time they leave the rivers as smolts and the time when they reappear, one or more years later, as adult fish. The results of tagging experiments conducted on the Scottish coasts suggest, however, that the feeding ground for the salmon from Scottish rivers may lie to the west or north-west of Scotland[1]. The present recapture is the first direct evidence supporting this suggestion.

We are much indebted to Dr. Jørgen Nielsen, of the Ministeriet for Grønland, for sending details of this recapture.

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[1] Menzies, W. J. M., "The Stock of Salmon. Its Migrations, Preservation and Improvement", 90 (London, 1949).

FORTHCOMING EVENTS

Monday, April 15

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Future of Plastics in Power Cables", opened by Mr. C. C. Barnes.

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Annual General Meeting, 5.50 p.m.—Mr. P. Winteringham: "Comparative Biochemical Aspects of Insecticidal Action".

Monday, April 15—Wednesday, April 17

SOCIETY FOR GENERAL MICROBIOLOGY (at the Royal Institution, Albemarle Street, London, W.1)—Twenty-fourth General Meeting.

Monday, April 15

At 6 p.m.—Dr. André Lwoff (Pasteur Institute, Paris): "The Notion of Virus" (Third Marjory Stephenson Memorial Lecture).

Tuesday, April 16

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Measurement of Currents in High-Voltage Circuits without Orthodox Current Transformers", opened by Mr. M. Kaufmann and Dr. A. J. King.

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. J. J. Foody and Mr. R. A. Paul: "Simulation Techniques in Aeronautics".

Tuesday, April 16—Wednesday, April 17

BRITISH OCCUPATIONAL HYGIENE SOCIETY (at Canterbury Hall, Cartwright Gardens, London, W.C.1)—Conference on "Instruments used in Industrial Hygiene".

Wednesday, April 17

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Annual General Meeting. Dr. R. C. Sutcliffe, F.R.S.: "An Outlook on Meteorology and the Society" (Presidential Address).

ROYAL SOCIETY OF MEDICINE, COMPARATIVE MEDICINE SECTION (at 1 Wimpole Street, London, W.1), at 5 p.m.—Discussion on "Artificial Insemination". Opening Speakers: Mr. L. E. Rowson, Dr. T. Mann, Dr. Margaret Jackson and Mr. Reynold H. Boyd.

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Discussion on "The Use of Electronic Data Processing Equipment". Opening Speakers: Mr. J. H. H. Merriman; Mr. D. T. Caminer; Mr. Evans; and Dr. H. Durant.

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Dr. D. McLean: "Modern Metallography and some of its Results".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Annual General Meeting, 6.15 p.m.—Prof. G. Pontecorvo, F.R.S.: "Applications of Genetics in Industrial Microbiology".

Thursday, April 18

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 3 p.m.—Symposium on "Weedkillers", opened by Prof. R. L. Wain, Dr. J. Stubbs, Mr. G. O. Lace, Miss Olive Balme and Mr. J. D. Fryer.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT PHYSICIST (with a good honours degree in physics) IN THE PHYSICS DEPARTMENT of the Sheffield National Centre for Radiotherapy—The Secretary, Sheffield Regional Hospital Board, "Broom Cross", Tree Root Walk, Sheffield 10 (April 20).

LECTURER (graduate, preferably with industrial experience in metallurgy and teaching experience) IN METALLURGY—The Principal, Herefordshire Technical College, Hereford (April 20).

ASSISTANT IN BIOCHEMISTRY to assist in the teaching of biochemistry to medical and science students and to engage in research under the direction of Prof. J. N. Davidson—The Secretary of University Court, The University, Glasgow (April 22).

CHAIR OF PHYSICS in the University College, Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 23).

ASSISTANT LECTURER (medically qualified or non-medically qualified) IN HISTOLOGY in the Department of Physiology and Histology—The Registrar, The University, Liverpool (April 27).

DEMONSTRATOR (with a good honours degree) IN THE DEPARTMENT OF ENGINEERING SCIENCE—The Professor of Engineering Science, The University, 19 Parks Road, Oxford (April 27).

DEMONSTRATORS (2) IN PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (April 30).

PLANT PHYSIOLOGIST (with research experience) IN THE BOTANY DEPARTMENT to work on the physiology of growth and nutrition of field crops—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (April 30).

SENIOR LECTURER and a LECTURER (Grade I) or (Grade II) IN CHEMISTRY at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 30).

STATISTICIAN (with a good honours degree in mathematics or science and experience in statistical techniques as applied to agriculture or biology) with the Agricultural Research Council's Unit of Statistics (University of Aberdeen)—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (April 30).

TURNER AND NEWELL RESEARCH FELLOWS IN ENGINEERING, INORGANIC CHEMISTRY, PHYSICS and allied subjects; and IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN CHEMISTRY, PHYSICS and allied subjects, for example, PHARMACOLOGY, ENGINEERING and METALLURGY—The Registrar, The University, Manchester (April 30).

SENIOR LECTURER or LECTURER IN ZOOLOGY at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 3).

ASSISTANT IN AGRICULTURAL CHEMISTRY—The Secretary of University Court, The University, Glasgow (May 4).

LEADER (with a university honours degree in science or agricultural science or equivalent qualifications, together with extensive research experience, preferably in tropical environments) of a research team in tropical agriculture at Kimberley Research Station in northern Western Australia (C.S.I.R.O.)—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 572/12 (May 4).

LECTURER IN CIVIL OR MECHANICAL ENGINEERING—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (May 4).

LECTURER IN VETERINARY PATHOLOGY AND BACTERIOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 4).

LECTURER (with a good honours degree) IN ZOOLOGY at the Nigerian College of Arts, Science and Technology—The Advisory Committee on Colonial Colleges, 1 Woburn Square, London, W.C.1 (May 6).

PROFESSOR OF TEXTILE TECHNOLOGY—The Registrar, The Manchester College of Science and Technology, Manchester 1 (May 6).

RESEARCH FELLOW (with research experience in animal virology or in biochemistry) IN THE DEPARTMENT OF MICROBIOLOGY, John Curtin School of Medical Research, Australian National University, to work in either biological or biochemical aspects of animal virology—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 6).

LECTURER IN CROP PRODUCTION to teach the principles of crop and grassland production; and a LECTURER IN ANIMAL PRODUCTION to teach primarily the principles and practice of meat and wool production—The Registrar, Wye College (University of London), near Ashford, Kent (May 15).

LECTURERS IN THE DEPARTMENT OF ENGINEERING, University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 15).

PLANT PATHOLOGIST (with a good honours degree in botany, with specialist knowledge and preferably research experience of plant pathology) at the Regional Research Centre, Imperial College of Tropical Agriculture, Trinidad, B.W.I.—The Secretary, Imperial College of Tropical Agriculture, 40 Norfolk Street, Strand, London, W.C.2 (May 15).

LIBRARIAN (preferably science graduate)—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (May 29).

LECTURER (preferably with experience in fluid mechanics) IN THE DEPARTMENT OF MECHANICAL ENGINEERING, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Cape Town, May 31).

PROFESSOR OF MATHEMATICS at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, May 31).

SENIOR LECTURER or LECTURER IN ZOOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 31).

ASSISTANT LECTURER IN PHILOSOPHY—The Registrar, Trinity College, Dublin (June 8).

NORTH THAMES GAS BOARD FELLOWSHIP IN GASEOUS FUELS AND COMBUSTION—The Registrar, Imperial College, London, S.W.7 (July 1).

AGRONOMIST (with a good honours degree and preferably some practical training) at GAMBIA RICE FARM, to undertake experiments in the cultivation of irrigated rice and of alternative crops suitable for dry season cultivation under irrigation—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/12/03.

ASSISTANT BIOCHEMIST (preferably with an honours degree) in a rapidly expanding department with university connexions—The Medical Superintendent, Maryfield Hospital, Dundee.

DIRECTOR OF THE AGRICULTURAL AND HORTICULTURAL RESEARCH STATION, Long Ashton, Bristol—The Registrar, The University, Bristol 8.

GRADUATE MASTER TO TEACH MATHEMATICS up to advanced level—The Director of Studies, Pangbourne Nautical College, Pangbourne.

LECTURER IN PETROLOGY-MINERALOGY; and a LECTURER IN STRUCTURE-ECONOMIC GEOLOGY—The Dean, College of Arts and Science, Baghdad, Iraq.

LECTURER or ASSISTANT LECTURER IN PHYSICAL OR INORGANIC CHEMISTRY at Makerere College (The University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

LECTURER (with an honours degree in chemistry and postgraduate experience of academic or industrial research) IN PHYSICAL CHEMISTRY—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

PHYSICIST or ELECTRICAL ENGINEER (with a first- or second-class honours degree or equivalent in physics or electrical engineering, and some electronics experience) with the Ministry of Supply at the R.A.E., Aberporth, Cardiganshire, to work in a section doing research

and development on electronic instrumentation—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.92/7A.

Physicist or Engineer (with postgraduate experience in the field of particle accelerators or vacuum and high frequency experience) with the European Organization for Nuclear Research, Geneva, Switzerland, for work on the design and development of bunching and focusing devices for a Proton Linear Accelerator—The Ministry of Labour and National Service (E9), Almack House, King Street, London, S.W.1, quoting A.12/SW.1/CERN/9.

Physics Technician for the construction of experimental equipment and general duties in connexion with X-ray treatment and radioactive isotopes—The House Governor, Charing Cross Hospital, London, W.C.2.

Qualified Technician (male or female) in the Pathological Laboratory—The Secretary, Wembley Hospital, Wembley, Middlesex.

Research Fellow (with some research experience) for work in the field of carbohydrate metabolism in plants—The Secretary, Research Institute of Plant Physiology, Imperial College, London, S.W.7.

Senior Experimental Officer (with H.S.C. (science) or equivalent) to assist in the planning and execution of overseas trials of atomic weapons; co-ordination of technical requirements of scientific and Service teams with a wide range of interests and participation in the trials—The Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. No. 1448/34.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

National Institute of Agricultural Botany. Farmers' Leaflet No. 2 (Revised January, 1957): Varieties of Spring Wheats and Spring Barleys—Recommended Lists for 1957. Pp. 4. Farmers' Leaflet No. 8 (Revised January, 1957): Varieties of Winter Cereals—Recommended Lists for 1957. Pp. 6. Farmers' Leaflet No. 13 (January, 1957): Varieties of Spring Oats—Recommended Lists for 1957. Pp. 2. (Cambridge: National Institute of Agricultural Botany, 1957.) [122

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Atomic Power. By the Technical Editor of the *International Year Book*. Pp. 8. (Extract from the 1957 edition of *The International Year Book and Statesmen's Who's Who*.) (London: Burke's Peerage, Ltd., 1957.) [152

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Dean Forest and Wye Valley. Edited by H. L. Edlin. Second edition. (National Forest Park Guides.) Pp. viii+95. (London: H.M. Stationery Office, 1956.) 5*s*. net. [152

Forestry Commission. Bulletin No. 27: Utilisation of Hazel Coppice. Pp. vi+33+32 plates. (London: H.M. Stationery Office, 1956.) 10*s*. net. [152

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Planning. Vol. 23, No. 407 (18 February, 1957): Agriculture and Land-use. Pp. 29–44. (London: Political and Economic Planning, 1957.) 2*s*. 6*d*. [182

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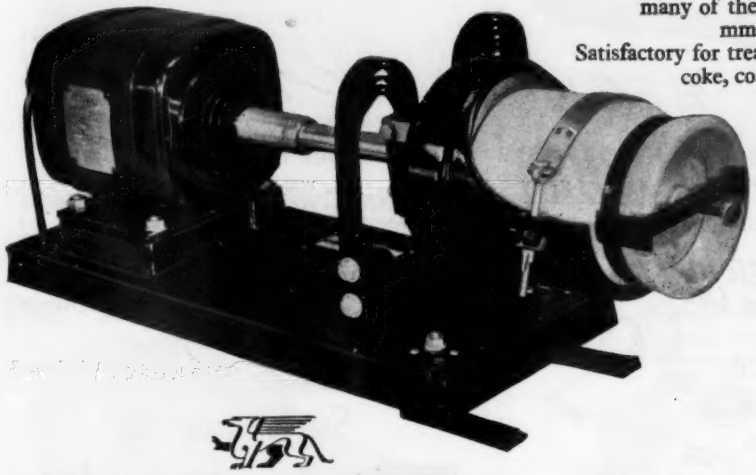

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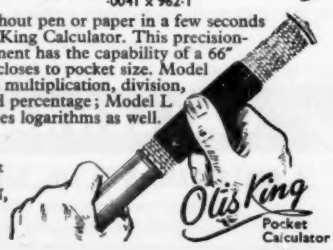

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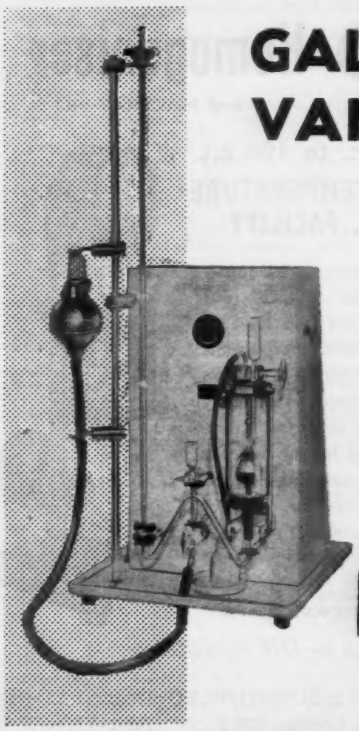

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